Ib. 39

PHOTOTHERAPY

(1) THE CHEMICAL RAYS OF LIGHT AND SMALL-POX.

(2) LIGHT AS A STIMULANT.

(3) THE TREATMENT OF LUPUS VULGARIS BY CONCENTRATED CHEMICAL RAYS.

BY

PROFESSOR NIELS R. FINSEN
COPENHAGEN

TRANSLATED FROM THE GERMAN EDITION AND WITH AN APPENDIX ON

The Light Treatment of Lupus

BY

JAMES H. SEQUEIRA, M.D. LOND., M.R.C.P.
DERMATOLOGICAL ASSISTANT AND MEDICAL OFFICER IN CHARGE OF THE LIGHT DEPARTMENT AT THE LONDON HOSPITAL
PHYSICIAN TO THE NORTH EASTERN HOSPITAL FOR CHILDREN

LONDON
EDWARD ARNOLD
37 BEDFORD STREET, STRAND, W.C.
1901

AUTHOR'S PREFACE

When I determined to publish the three memoirs which follow, it was with the intention of directing the attention of physicians to the medical and biological importance of light, and especially of the chemical rays. These papers have appeared at different times: the first in *La Semaine Médicale* of June 30, 1894, under the title 'Les rayons chimiques et la variole'; the second, in Danish, in the *Hospitalstidende*, of Copenhagen, No. 8, 1895—'Lyset som Incitamen' ('Light as a Stimulant'); and the third in *La Semaine Médicale* of December 21, 1897—'Traitement du lupus vulgaire par les rayons chimiques concentrés.'

As, for various reasons, I have not been able to rewrite them, their form has not been changed, with the exception of some corrections and supplementary remarks. I beg the reader to be kind enough to excuse their present form. The last article especially is only a very condensed summary. For further information I must refer to my previous publications upon this subject, to what I shall shortly bring out, and to the communication made by my friend and collaborator, Dr. Bang, at the Fourth Congress on Tuberculosis at Paris in 1898.

To the articles appendices have been added, and several new illustrations are included.

In Denmark these researches have been followed for a long time with much interest. A public institution, supported by the State, has been established, with this programme: 'To make and support scientific research concerning the action of light upon living organisms, and especially to apply the results to the service of practical medicine.' The institute, founded in April, 1896, in great part by the generous donations of Mr. G. A. Hagemann and Mr. Vilh. Jorgensen, contains laboratories and a clinic for the carrying out of phototherapy, and particularly for the treatment of lupus and other diseases of the skin by concentrated chemical light.

NIELS R. FINSEN.

COPENHAGEN,
July, 1901.

TRANSLATOR'S PREFACE

Professor Finsen's work has of late attracted so much attention in this country that an English version of his original communications will, I feel sure, be received with interest. In the translation I have carefully followed the original, and have added one or two notes, particularly where there have been improvements in the apparatus. As an appendix to the article on the treatment of lupus by concentrated chemical rays, I have given a résumé of the present position of the treatment, based upon a recent paper by Dr. Forchhammer, who is in charge of the clinic at the Finsen Light Institute at Copenhagen.

JAMES H. SEQUEIRA.

Welbeck Street,
August, 1901.

CONTENTS

PHOTOTHERAPY

THE CHEMICAL RAYS OF LIGHT AND SMALL-POX

(1894)

In July, 1893, I proposed a new treatment for small-pox,[1] which consists in placing the patients in rooms from which the chemical rays of the solar spectrum are excluded by interposing red glass or thick red cloth. The result of this method of treatment is that the vesicles as a rule do not enter upon the stage of suppuration, and that the patients get well with no scars at all, or at most with extremely slight scarring.

This treatment of variola, which is important from the results which it has given, and remarkable for the new therapeutic principle which underlies it, demands a detailed explanation as much from the theoretical as from the clinical side. The theoretical aspect which I shall consider immediately concerns the injurious influence of the chemical rays in general. This influence, which is not confined to variola, depends upon a principle which will, perhaps,

[1] N. R. Finsen, *Hospitalstidende*, July 5, 1893.

find its practical application in other exanthematous and cutaneous affections. Moreover, this preliminary study will enable us to understand better the therapeutic effects obtained by the method which I recommend.

It must be acknowledged that, with the exception of the influence of light upon plants and upon the organ of vision, our knowledge of the physiological action of light and its effects, whether good or bad, is very limited. In undertaking now the study of one of the properties of the chemical rays, viz., their injurious influence upon the animal organism, I do so, not because I regard this property as the only influence of the chemical rays, but because it constitutes the very foundation of our subject.

The so-called chemical rays, placed in the blue, violet, and especially the ultra-violet parts of the spectrum, are the most refrangible ; the chemical effect is here at the maximum, the heating effect at the minimum.

The other extremity of the spectrum presents the opposite phenomena ; there the red and ultra-red rays are the least refrangible, and the chemical effect is at the minimum.

These two kinds of rays, the red and the violet, also appear to produce very different physiological effects. The violet rays seem to have a more intense action—at least, their influence is more evident. If a series of observations relative to the influence of monochromatic light are brought together and compared, it will be seen that, with the probable exception of plants, living organisms are unfavourably influenced by it. If the chemical rays are

sufficiently intense, the action becomes plainly harmful.

It is generally known that light produces a deleterious or fatal influence upon bacteria, at least upon the majority of them. Duclaux,[1] who made a series of investigations upon these phenomena, says that sunlight is the best, cheapest, and most universally applicable bactericidal agent that we have.

According to the researches of Downes and Blunt[2] on the influence of monochromatic light, this effect is due, if not exclusively, at least in very great part, to the chemical rays. Arloing[3] found in experiments with the *Bacillus anthracis* that this organism grows better in darkness and in the less refrangible rays than in those which are more refrangible. Geisler[4] obtained the same result in experiments with the typhoid bacillus. Among the numerous observers who have taken up this subject, D'Arsonval and Charrin[5] must be mentioned. In their researches on the *Bacillus pyocyaneus*, they have shown that the chemical are the only rays which have a destructive influence upon this organism, and that the difference between the chemical

[1] Duclaux, *Comptes rendus de la Soc. de Biol.*, 1885, p. 395; and *Semaine médicale*, 1885. p. 22.

[2] Downes and Blunt, *Proceed. of the Royal Society of London*, vol. xxviii., 1878, p. 199.

[3] Arloing, 'Influence de la lumière sur la végétation et les propriétés pathogénes du *Bacillus anthracis*' (*Semaine médicale*, 1885, pp. 46, 293, and 309).

[4] Geisler, 'Sur l'action de la lumière sur les bacteries' (*Arch. de méd. experim. et d'anat. path.*, November, 1891, p. 800).

[5] D'Arsonval and Charrin, 'Influence des agents atmosphériques en particulier de la lumière et du froid sur le bacille pyocyanique' (*Semaine médicale*, 1894, p. 26).

and the calorific part of the spectrum is most marked.

Graber,[1] in his researches upon the effect of light upon the earthworm, found that this animal is photophobic, and always crawls away to the darkest places. Red light is equivalent in its action to darkness, while the dark-blue and especially the ultra-violet rays produce the effects of ordinary light. Entire worms and decapitated worms presented the same phenomena.

Dubois[2] made analogous experiments with the proteus, an animal which, like the earthworm, prefers the dark. By measuring the time which elapsed before this batrachian reacted to different luminous rays, he found that its comfort appeared to diminish from agreeable obscurity to disagreeable light, according to the following scale: Darkness, red light, yellow, green, violet, blue, white light.

The chameleon also presents very interesting phenomena. It is known that it changes its colour, and this, according to Brücke,[3] is due to the change of place of the pigment cells of the skin, called chromatophores. In light these remain at the surface of the integument, in darkness they lie deeper. A slow transition from darkness to light produces a scale of coloration in this animal which becomes successively whitish, gray-green, then spotted with black, and finally brownish-black in colour. In other words, this reptile possesses pigment cells which it moves when it wishes to protect itself against a disagreeable light impression.

[1] Graber, quoted by Bournoff (*Arch. f. Hyg.*, x., p. 339).

[2] Dubois, *Comptes rendus de la Soc. de Biol.*, 1890, p. 360.

[3] Brücke, *Sitzungsber. d. Wien. Acad.*, 1851, ii., p. 802.

Paul Bert made, and Hoppe-Seyler[1] confirmed, the observation that red and yellow light have no influence upon the chromatophores, while the blue and violet rays produce a strong reaction. Paul Bert[2] further observed that by illuminating one half of the body of a chameleon through a red glass, and the other half through a blue glass, the colour of the animal becomes almost instantaneously blackish under the blue glass, while it remains for a long time whitish under the red glass.

Horses and horned cattle are, like man, subject to solar erythema. This erythema, as several veterinary surgeons have informed me, is limited almost exclusively to the non-pigmented parts of the skin. The ultra-violet rays are especially the cause of this. I shall return to this subject later. Wedding[3] further describes a very interesting observation, the truth of which Virchow has confirmed. He says that he has noticed that cattle and sheep fed upon buckwheat are subject to vesicular cutaneous eruptions. All the animals, however, did not become affected ; but the lesions were much more marked in the whiter animals and in those which were more exposed to a diffused light and to the direct rays of the sun. Animals which were kept in the dark did not present any eruption. A white cow, which was coated upon one side of the body with tar, had the exanthem only upon the opposite side. In the same way, animals with a variously-coloured skin were

[1] Hoppe-Seyler, *Physiologische Chemie*, 1881, p. 25.

[2] Paul Bert, *Revue scient.*, 1878, p. 987.

[3] Wedding, *Verhandl. der Berl. Gesellsch. für Anthropologie*, 1887, p. 57.

only affected over the light parts of their integument.[1]

As far as the human race is concerned, this harmful influence of the chemical rays is especially manifested in the form of eruption called erythema solare, or eczema solare. It was formerly believed that the heat rays of the sun were the cause of this disease, as the name erythema, or eczema caloricum, would seem to show. Pigmentation was also believed to be due to the heat rays of the sun, as well as to the temperature and the open air; but it is now definitely known—as the experience of Unna[2] of Hamburg, of Widmark[3] of Stockholm, and of Hammer[4] of Stuttgart has shown—that it is exclusively the chemical rays of the spectrum and particularly the ultra-violet rays which are the agents in the production both of the pigmentation[5] and of the solar eczema. That it is not the effect of heat is clear from the observations of Widmark upon the explorers of the polar regions, and from those of Hammer upon the tourists on the glaciers.

[1] An observation made upon the calves used in the manufacture of animal vaccine is especially interesting. It was found that the pustules do not develop well upon calves with a dark hide, and consequently calves with a light skin are preferred for this purpose. Livius Fürst ('Der gegenwärtige Stand der animalen Vaccination'; Volkmann, *Sammlung klinischer Vorträge*, No. 30, 1891, p. 332) notes this fact —without trying to explain it—as learned practically. The observation was made before I had drawn attention to the influence of light upon variola.

[2] Unna, 'Ueber des Pigment der menschlichen Haut' (*Monatschr. f. Dermatol.*, 1885, p. 285).

[3] Widmark, 'Ueber den Einfluss des Lichtes auf die Haut' (*Hygeia*, iii.).

[4] Hammer, 'Ueber den Einfluss des Lichtes auf die Haut,' Stuttgart, 1891.

[5] It is understood that I speak here only of the physiological pigmentation of parts of the skin exposed to light.

Even at a temperature below zero these travellers may suffer severely from the erythema caused by the strong reflection of sunlight from the fields of ice. It was Charcot[1] who in 1859 expressed the opinion that it was the chemical rays and not the heat rays which are active in these cases, and that the dermatitis caused by a very strong electric light is identical with erythema solare. But it was not till 1889 that Widmark gave the scientific proof of this.

These two effects of the chemical rays upon the skin—the erythema being considered as the acute, and pigmentation as the chronic, form of the cutaneous manifestation—are so intimately connected that it would seem that they should not be described separately; but I believe that it is necessary here in order to render their study together more easy. Pigmentation may be regarded as a useful process, inasmuch as the colouring matters prevent the luminous rays penetrating too deeply, and thus protect the skin against their inflammatory action. This conception of the function of pigmentation is that which Unna, I believe, was the first to set forth in 1885. But, without knowing his opinions, I had arrived at the same idea in endeavouring to account for the causation of the pigmentation in negroes.[2] To prove the exactitude of this hypo-

[1] Charcot, *Comptes rendus de la Soc. de Biol.*, 1859. p. 63.

[2] Waitz (*Anthropologie der Naturvölker*, 1877, pp. 39, 40) says that two hypotheses have been made to explain the coloration of the skin of the negro. One is based upon the incomplete oxidation caused by the heat, the consequence of which would be the deposition of carbon in the skin; the other sees in it the effect of the vegetable diet—that is to say, the very carbonaceous nature of the material which forms the basis of the food of the negroes. Darwin deals with this question,

thesis, I made during the summer of 1893 some experiments upon my forearm, which is quite unpigmented and which I commonly keep covered. To imitate the colour of the negro's skin, I traced in Indian ink upon my forearm a band about 2 inches wide, and then exposed it for about three hours to a very hot sun. I then removed the black colour, and the skin under it appeared perfectly white and normal, whilst that on each side was red. After some hours a very well-marked erythema, accompanied by pain and slight swelling, developed. The lines between the affected and the normal parts of the skin were extremely clear, and showed the same little irregularities which existed at the edges of the black band. The erythema lasted several days, and finally the skin showed a fairly strong pigmentation, while the rest was normal. I once more exposed the same arm to the sun, but this time without having blackened it. The result was completely reversed : the white zone became the seat of the erythema, while the parts at the sides had not changed in appearance—they were perhaps a little more pigmented.

In daily life we meet with many other examples of the truth of this hypothesis. Oarsmen, who make a long row at the beginning of the season with bare arms, are often attacked with severe

---

pointing out that different phenomena show that the colour of the skin and fur is sometimes in startling correlation with a complete insensibility to certain vegetable poisons and to the attacks of certain parasites. He conceived that the black colour of negroes and other races, acting through a long series of generations, prevented these individuals from being attacked by the fatal miasmata of their country.

erythema solare upon the parts of the limbs which are unaccustomed to light, while their pigmented hands, which have nevertheless been exposed to the same influence, do not react. At the end of such an erythema the arm becomes pigmented in its turn, and bears the action of the sun's rays well.

The colour of peoples and different races is thus easily explained : the nearer we approach the equator the darker the coloration of the skin becomes, and the more remote we go the lighter it is. The red and yellow colours of the Indians and Mongolians present characters of practical value in that they absorb all the chemical rays, but the black skin absorbs the luminous rays still more. It is obvious that there are exceptions, and that hereditary disposition transmitted from generation to generation plays an important part. But, speaking generally, a European who lives in tropical countries notices that his skin takes on a darker coloration, while the black colour of negroes who come to Europe is diminished in a sensible degree.

In the animal kingdom pigment seems to play an analogous part. As I have said before, it is well known that erythema solare affects horned cattle and horses with a spotted coat almost exclusively in the light areas, while the dark parts are not affected. Without refusing to recognise the part played by other causes, I should like to draw attention to a phenomenon which exists amongst almost all animals—that is, that the surface most exposed to the rays of the sun, the back, is usually the most strongly coloured, and thus better protected than the surface of the abdomen. Examples of this are

found almost everywhere—amongst furred animals, whales, reptiles, birds, fish, etc. The plaice shows rather interesting features. It is known that it is not pigmented on the back, but upon the upper surface—that is, upon the side turned towards the sun. It is further known that the colour is not always upon the same side. 'Reversed' plaice are equally coloured upon the side exposed to light. To understand this it is necessary to remember that water absorbs the red and ultra-red rays in a high degree, and allows the ultra-violet to pass freely.

Among polar animals, pigmentation seems to vary in relation to light. There exists a connection between the black colours of the summer, which is so rich in light, and the whitish hues of the winter, which is so dark.

These phenomena of the animal kingdom are not different from what we see in man in a less degree. The part of our skin exposed to light is commonly more pigmented than the rest, and still more so in summer than in winter.

In the vegetable kingdom fairly analogous phenomena are observed. Too much light destroys plants, hence Nature protects them in different ways against a too strong sun. In the epidermal cells of plants a colouring matter is deposited for this purpose, as we observe in beech-trees, red beet-roots,[1] and in the majority of young delicate shoots. We know that in the same plant the leaves exposed to light become red, while those which grow in the shade are all green.[2]

[1] Johannsen, 'Laerebog i Plantesfysiologi,' p. 311.
[2] Hoppe-Seyler, *loc. cit.*, p. 24.

The acute effects of the chemical rays upon the human skin are manifested in all degrees, from a feeble irritation and a slight redness, to an inflammation followed by epidermal desquamation. The degree of the lesion depends upon the intensity of the light, and upon the proportion of chemical rays in it. With regard to artificial illumination, ordinary lamps give proportionately less, and the electric light more, chemical rays than the sun. The intensity of the affection also depends upon the duration of the exposure to the light, and upon the greater or less pigmentation of the skin, perhaps also upon the thickness of the epidermis, for we see that the palm of the hand and the sole of the foot in the negro are white, and we know that the epidermis is thicker in these situations. It is right to remark that these two regions are but little exposed to luminous rays; but the palm of the hand is more accessible than the axillary cavity, for instance.

This inflammation differs in one particular from every other of the same duration, in that it leaves pigmentation of the skin. Moreover, it is distinguished from an inflammation caused by heat, because it does not develop immediately, but only after the lapse of a certain time, and does not reach a high degree until from twelve to twenty-four hours after the action of the light. Finally, it develops exclusively upon the parts directly exposed to the luminous rays, whereas heat rays may also act through the clothes.

This acute form of the action of the chemical rays is naturally met with more often in people in whom

the skin is only slightly pigmented (blondes) than in others. Albinos suffer severely.

It is in the spring that the skin is most easily affected, not because there are more chemical rays at this season, but because the epidermis and the pigment which it contains are weakened—used up during the winter.[1]

Naturally, the parts most exposed to vertical light—the bridge of the nose and the cheeks, for instance—are those which react the most. The tourists upon the glaciers often suffer from a solar erythema, as I have already mentioned, because the fields of ice reflect the rays of light, and especially the chemical rays. But here the light comes from below, and for this reason the skin of the lower part of the nose and of the chin are particularly affected.

In summer the skin has received its protective layer of pigment, and inflammation is rarer. It is localized chiefly between the pigmented regions of the skin and those unpigmented, where a very clear line of demarcation is so often seen.

In the spring, rowing-men, as I have already said, are often subject to well-marked erythema solare. After a first excursion of some duration made in the sun, their arms become the seat of a violent inflammation, which attains its maximum on the following evening or night. One evening I saw two oarsmen with their arms red, dark, and swollen, compelled by pain to rest them upon the table, fearing the

[1] I here allude to phenomena observed in northern countries (Denmark).

least movement. The following night the pain prevented them from sleeping.

The great strength with which the chemical rays may act is clearly shown in the remarkable experiments of a French physician, Dr. Defontaine (of Creusot),[1] and of the Russian physician Maklakow, relative to the effect of a strong electric light upon the skin and eyes. Dr. Maklakow's observations were made at Kolomna, three hours' journey from Moscow, where in a large foundry metals are smelted by electricity. A light of such intensity, and so deleterious to the workmen, is developed in this process, that, although they receive supplementary pay, the men prefer harder and less remunerative work rather than undergo such suffering. Dr. Maklakow[2] was called in to advise a means whereby the workmen could be protected against the harmful action of the light, and for this purpose he subjected himself to the following experiment :

On December 5, 1888, at 10.45 a.m., Maklakow was present at a welding made by the voltaic arc from 250 accumulators. He, like the workmen, wore black spectacles, without which he was unable to look at the arc light for more than two seconds. At 11.30 the experiment was finished. Even on his way home he felt a pricking sensation in the skin, and this increased. Soon after, coryza, lachrymation, and an irritable cough came on.

At 2.30 in the afternoon Maklakow exposed him-

[1] Defontaine, 'Coup de soleil électrique' (*Semaine médicale*, 1888, pp. 5, 6).

[2] Maklakow, *Arch. d. Ophthalmol.*, 1889, p. 97; and *Semaine médicale*, 1889, p. 40.

self for ten minutes more to the electric light. At 4.40 it was impossible for him to open his eyes. He felt a burning sensation on the left side of his face and neck; he was photophobic and restless, and his pulse was 96 per minute. After a short sleep all the symptoms increased in severity. The almost unbearable pain necessitated the injection of cocaine. In the evening his face was dark-red and greatly swollen, and severe chemosis of the ocular conjunctiva developed. The pain lasted the whole night, and all the parts which had been exposed to the light were acutely inflamed. A remarkable fact was that the conjunctiva of the lids was not at all swollen, in spite of the bulbar chemosis.

The next morning the pain in the eyes diminished, a muco-purulent discharge from the conjunctivæ appearing at the same time. The inflammation of the skin increased still more; it became œdematous, of a dark-red colour, hot, dry, irritable and tender to the touch. The evening of the same day the symptoms abated, and during the night the epidermis began to separate. Some days later the skin desquamated in large flakes, as after scarlatina, and there only remained slight pigmentation of the integument, especially of the neck.

It is unnecessary for me to add that the heat radiation from the electric furnace was comparatively slight, and it is therefore impossible to attribute the affection from which M. Maklakow suffered to the effects of heat. A burn is followed by immediate pain, while in the present instances the suffering only occurred after the lapse of some hours. The differences between these two kinds of lesions I

have set forth above. It is somewhat different with solar erythema, for the distinction is not seen in so clear a manner. That it is not a burn—*i.e.*, that it is not due to the heat rays of the spectrum, as was formerly believed—is a point not easy to determine. I have therefore deemed it not unnecessary to dwell a little upon the reasons which lead us to believe that it is the chemical rays and not the heat rays which cause this irritation of the skin. Professor Widmark[1] of Stockholm has demonstrated this.

He employed for his experiments an electric arc of 1,200 candle power. To eliminate the effects of heat he made the light pass through a layer of water of sufficient thickness to absorb the heat rays. By passing the light through a plate of ordinary glass, he was able to exclude the ultra-violet rays. He then observed the effect produced upon the skin by excluding the two kinds of rays alternately. These are the chief results obtained :

1. Under the influence of all the rays of light, except the ultra-violet, the skin was unaffected.

2. Under the influence of all except the heat rays, the characteristic inflammation developed. These researches, accompanied by control experiments, show that it is not the heat rays, but the ultra-violet especially, which produce the known effects of light upon the skin.

II

Having thus considered the macroscopic phenomena, and having studied the particular in-

[1] Widmark, *Hygeia*, Festband iii.

flammation caused by a special irritant, it seemed to me profitable to learn what histological changes are produced, in fact, to know whether a simple inflammation develops or not. To obtain a clear idea of this, early in 1893 I carried out some experiments on the influence of the sun's rays upon tadpoles.[1]

Few animals are well adapted to this kind of research, but I chose the tadpole as most suitable for the object I had in view. The body of the animal was enveloped in a filter-paper soaked in water, and then placed upon the stage of the microscope. The tadpole was then exposed to the rays of the sun, and constantly moistened with cold water, which permitted its being kept alive and excluded the heat rays. After ten to fifteen minutes changes occurred. In the capillaries which were dilated the circulation slowed, and finally ceased altogether, and gradually leucocytes and red corpuscles were seen to have made their way outside the capillaries, as in simple inflammation. I also observed that the red corpuscles changed their shape under the same influence. They became compressed, and more round; in other words, they contracted. It is further well known that light rays may cause the contraction of living protoplasm. Auerbach[2] has seen daylight, especially direct sunlight, cause an energetic contraction of the protoplasm of the eye of the frog.

Engelmann[3] says that the *Pelomyxa palustris* (a

[1] N. R. Finsen, 'Recherches sur l'inflammation provoquée par l'action de la lumière solaire' (*Semaine médicale*, 1893, p. 470).

[2] Auerbach, *Centralblatt f. d. Med. Wissenschaft*, xix., p. 1.

[3] Engelmann, *Pflüger's Archiv.*, xxxv., p. 1.

kind of amœba) contracts strongly when exposed suddenly to light, but that it quickly expands under the influence of a sudden darkness. The same author[1] has pointed out that the rods and cones of the retina shorten in light and lengthen in darkness.

So far as I am aware, this kind of inflammation has not yet been the subject of microscopical research, and Hammer[2] is, I believe, the only one who has studied this phenomenon from the theoretical aspect. He does not believe in the direct action of the light upon the blood capillaries, but supposes that certain nervous elements of the skin in connection with the pigment cells are put in motion by the ultra-violet rays, and that this leads secondarily to the paralytic conditions: hyperæmia, inflammation and pigmentation.

Light doubtless exercises a general influence upon the organism (especially through the optic nerves), but there exist many phenomena—and I shall consider some of them—observed in my own researches which are in favour of a direct action upon the blood capillaries and upon the blood itself.

Starting with the fact that pigmentation constitutes a defence against the effects of the chemical rays, the observation of the manner in which the pigment is laid down would lead to the discovery of the very part of the skin which has need of being protected. In man the pigment is essentially placed in the deeper layers of the epidermis. There

[1] Engelmann, *Pflüger's Archiv.*, xxxv., p. 498.
[2] Hammer, *loc. cit.*, p. 47.

are no capillaries in the epidermis itself, but in the layer immediately under it, the stratum papillare. In animals the pigment cells are more disseminated; they are often to be met with along the vessels of the skin. In reptiles complete tubes of pigment are seen around the vessels. It seems, then, that the vessels and the blood are in need of protection.

I desire to draw attention to one other point, the absorption of light. I am well aware that physical laws cannot always be used to explain physiological cases; but as certain laws are in accord with vegetable physiology, it is probable that they apply also to animal physiology. It is admitted as a law of physics that it is only the light which is absorbed by bodies which acts upon these bodies, and that the chemical influence of light is in direct proportion to the light absorbed. When for this purpose we examine the animal organism we find that no living tissue absorbs so much light as the blood, and, more than that, the blood absorbs a considerable quantity of the violet rays.

As will be seen in the following article, my later experiments show that light has a considerable influence upon the nervous system, at least in the lower animals.

Before closing these remarks upon the action of the chemical rays upon the healthy body, I repeat what I said at first, that I do not in any way regard the harmful effects of the chemical rays as a definitely isolated phenomenon, for we see that these rays are only injurious when they act in great number and for a long time. In moderate amount they are certainly useful. In the chemical rays, as

in the heat rays, there is probably a mean which is agreeable and useful, an excess of the heat rays producing combustion.

III

We now come to consider the acute affections which the chemical rays may produce. It will then be easy to understand that some chronic diseases of the skin are dependent upon light both as to their origin and their course. Unna thus speaks of light as an etiological factor in the commonly fatal disease called melanosis lenticularis progressiva (xeroderma pigmentosa). To begin with, the first spots of pigment appear as freckles exclusively upon parts of the skin which are exposed to the sun, and the sun's rays exercise a decidedly unfavourable influence upon the increase and the progress of the tuberosities. Upon pellagra, and the summer prurigo of Hutchinson, light undoubtedly exercises a decided influence, the erythema clearly developing from the action of the sun in the spring.

Vejel[1] and Wolters[2] have described cases of quite remarkable sensitiveness in otherwise normal skins. After an exposure of some minutes to the sun an erythema developed. The patient could bear neither the direct rays of the sun nor diffuse daylight. In Vejel's case a slight irritation was even produced upon the side of the face which was turned towards the closed window of the room in which the patient

[1] Vejel, 'Ueber einen Fall von Eczema solare' (*Vierteljahressch. f. Dermat. u. Syph.*, 1887, p. 1113).
[2] Wolters, *Ergänzungsheft. z. Arch. f. Dermatol. u. Syph.*, 1892, p. 187.

lived. Vejel ordered the patient to wear a thick red veil, with an excellent result.

Another group[1] is formed by the diseases which, without depending etiologically upon the chemical rays, are always unfavourably influenced by them, which, for instance, is the case in variola. It is impossible to say whether we shall in the future include other diseases in this group. This is not improbable, *for what is more natural than that the chemical rays should exert an injurious influence upon a diseased skin, when we see such severe inflammation produced by their influence upon the healthy skin?*

Before approaching the clinical part of these observations, I will once more draw attention to the fact that I have deliberately confined my remarks to the local harmful action of light upon the skin. To avoid making the development of the theoretical part of my subject too long, I have excluded an examination of the general action of light upon the organism, an action which, so far as variola is concerned, is perhaps limited enough. I pass on now to the treatment of variola by the exclusion of the chemical rays of light.

IV

Facts bearing upon the unfavourable action of light upon the course of small-pox are found in medical literature. In 1832 Picton[2] described this phenomenon, and in 1867 and 1871 some English

[1] I am not alluding here to ocular affections in which special circumstances may be present.

[2] Picton, *Archiv. gén. de Méd.*, xxx., p. 406.

physicians—Black,[1] Barlow,[2] and Waters[3]—noticed it. But these observations have received little attention, and have been overwhelmed by the infinite number of methods which have been recommended at different times to avoid the formation of scars. Whilst studying the effects of light, I was led to interpret these different observations, and I found that from a theoretical point of view they were very reasonable and agreed very well with the fact that the face and the hands, the parts of the body exposed to light, are the seats of the deepest and most confluent scars. I saw clearly that the chemical rays would play an important part in this, and that is why I proposed in July, 1893, to treat patients suffering from small-pox in rooms from which the chemical rays had been excluded by filtering the light through thick red curtains. At the same time I showed the theoretical principle of the treatment, which had been hitherto wanting, and soon afterwards the method was tried.

The first trial was made at Bergen in Norway by Dr. Lindholm,[4] chief physician of the military service, and by Dr. Svendsen. They treated eight patients by red light. Four of these were unvaccinated children, presenting for the most part confluent vesicles upon the face and hands. Dr. Svendsen[5] speaks thus of the results: 'The clinical picture of the patients treated according to this method shows the following anomalies: The period of suppuration, the most

[1] Black, *Lancet*, 1867, i., p. 792.
[2] Barlow, *Lancet*, 1871, i., p. 151.
[3] Waters, *Lancet*, 1871, ii., p. 9.
[4] Lindholm, *Hospitalstidende*, September 6, 1893.
[5] Svendsen, *Medicinsk. Rev.*, October, 1893.

dangerous and most painful stage of small-pox, did not appear; there was no elevation of temperature, and no œdema. The patients entered the stage of convalescence immediately after the stage of vesication, which seemed a little prolonged. The hideous scars were avoided.'

Later, Juhel-Renoy[1] tried the same treatment at the hospital at Aubervilliers upon twelve patients. The results were not absolutely favourable, which was owing, I believe, to the fact that the chemical rays were only partially, and not absolutely, excluded. His description of the installation seems at least to indicate this. In spite of these results, Juhel-Renoy considered that the method of treatment ought always to be recommended.

In January, 1894, Professor Feilberg, physician-in-chief at the Small-pox Hospital in Copenhagen, treated eleven patients in this manner, with the following results. He says: 'Of the eleven patients I have treated by Dr. Finsen's method, by the exclusion of the chemical rays of light, three unvaccinated infants were cases of such severity that a more or less prolonged fever of suppuration was to be expected. But in no instance did this fever develop. In all the patients the vesicles began to dry up from the ninth to the eleventh day of the disease, and the patients entered the convalescent stage at once. In every instance the patient left the hospital with pigmented or hyperæmic spots, but without loss of the substance of the skin.'

[1] Juhel-Renoy, 'Sur le traitement de la variole par l'obscurité' (*Semaine médicale*, 1893, p. 557; and *Bull. et mém. de la Soc. méd. des Hôp. de Paris*, December 14, 1893).

Dr. Strangaard, cantonal physician of the Island of Amager (Denmark), has treated four cases of variola by this method. This is what he says: 'I have a very clear impression that this treatment exercises a favourable influence upon the exanthem. The papules do not undergo the usual changes into vesicles and pustules, but remain stationary for several days, and dry up gradually, and finally disappear entirely; in other words, there is a retrograde metamorphosis. In one of the patients—an unvaccinated infant, which was submitted to the treatment very late—some of the vesicles suppurated, and left some slight scarring, but this did not happen in any of the others.'

In February, 1894, Dr. Benckert, physician-in-chief of the Health Department at Gothenburg (Sweden), treated sixteen patients (eleven of variola vera and five of varioloid) by red light. Three died: one woman from puerperal infection, after having had small-pox without suppuration of the vesicles; a second patient from hæmorrhagic small-pox before the stage of suppuration; and the third from the fever of suppuration. Dr. Benckert expresses himself thus upon the treatment: 'In the grave cases of small-pox, it gave the most surprising results. I can say, as the result of my experience, that suppuration is usually abolished by this treatment. Scars are extremely rare, and, if they do occur, they are insignificant. The duration of the disease is shorter.'

The deleterious influence of light in small-pox has not only been determined by these good results, but also by some very fine control experiments. Dr. Svendsen made some of his patients go out into day-

light after the complete drying up of the vesicles on the face, but while there were still some vesicles upon the hands. These latter suppurated, and left scars, while there was not one anywhere else. One of Dr. Feilberg's patients was exposed to daylight while some of the undried vesicles were present upon the ear, and these suppurated. In another small-pox patient, an unvaccinated infant with confluent vesicles, suppuration had already commenced when it was submitted to the treatment. It became intense, and innumerable scars persisted in the facial region; but on the hands, where, as is usually the case, the vesicles were less advanced, they dried up without suppuration, and the child was absolutely free from scars in this part.

V

When we come to study the effect of light upon small-pox, it is interesting to see that many—one might almost say the majority—of the methods employed to avoid scarring, although arrived at empirically, have this point in common, that they preserve the skin from the influence of light. If the methods were of value, it is doubtless for the same reason. I will cite some examples: coating the face with tincture of iodine, or a strong solution of nitrate of silver; covering the face with a mask or compress spread with or soaked in an endless variety of thick and fatty materials. All these expedients protect the skin partially from the light. The tincture of iodine, which stains the skin yellow, protects it specially

from the chemical rays. The solution of nitrate of silver also absorbs these rays, and, later, stains the skin black—a phenomenon by which the rays are excluded. The utility of these substances, which have been used to soak or coat the compresses, is thus explained. Each substance had its advocates, but no one guessed that it was not so much the nature of the substances used, but the compresses themselves which protected the skin from the light. Coste, who recommended compresses soaked in boric acid lotion, noted the important fact that, where the compresses did not completely cover the skin, scars were produced, but not otherwise. It is obviously reasonable to use this observation in favour of the theory of the noxious influence of light.

I note here, on the authority of Dr. Julius Petersen, the learned professor in the University of Copenhagen, as a historical medical curiosity, that in the Middle Ages red bed-covers, and red globes placed in the beds—in fact, red surroundings—were used in the treatment of small-pox.[1]

[1] Dr. Œttinger has also recalled in his recent article (*Semaine médicale*, 1894, p. 257) that already in the eighteenth century Fouquet, of Montpelier, had seen in his childhood little patients suffering from small-pox clothed ' in scarlet cloth, or kept in beds closed with curtains of the same material, resembling what is stated to be the practice still in Japan.'

On the other hand, soon after the publication of Dr. Ehler's article on Dr. Finsen's first experiences, we received from one of our Roumanian readers—Dr. Capitanovitz, of Alexandria—the following note: 'In Roumania it is an old popular practice to cover the face and body of small-pox patients from the commencement of the disease with a piece of red cloth, because it is believed that the red colour attracts the eruption to the surface of the body, and that the complications which are likely to supervene upon an undeveloped eruption are thus avoided.'

Dr. Lassabatie (surgeon in the French Navy) has lately addressed us a letter, from which we extract the following passages :

Doubtless the red coverlets were arrived at empirically, and, later, it was sought to explain their utility by saying that the red colour irritated the blood, and provoked a more intense exanthem, which was regarded, according to the ideas of the time, as an advantageous result.

I shall conclude by indicating the principal points of the treatment, and the conditions to which attention should be given to obtain favourable results:

1. The exclusion of the chemical rays must be absolute. The thickness of the red material employed to filter the light depends upon its nature. If paper or thin cotton material is used, four or five layers will perhaps be sufficient. If rather thick flannel is employed, two or three layers will suffice. It is more convenient to employ red glass, but in

---

'The article which has just been published in the *Semaine médicale* on the treatment of small-pox by what is called the red-room method has reminded me of facts of which I was a witness at Tonkin during my last residence there two or three years ago.

'On several occasions I have had to treat natives suffering from small-pox, and I have always observed that before my arrival the patients had been carefully isolated in a kind of alcove hermetically sealed by numerous red hangings, and in which the darkness would have been absolute if one had not taken care to have a lamp lighted.

'I have every reason to believe that the Tonkinese did not know Finsen's method, which I was not myself aware of at that time; but it is rather curious to observe in this country the existence of a custom, no doubt of great antiquity, and to compare it with a procedure which the West seeks to establish in a scientific manner.

'It is difficult for me to say how many cases I observed and their degree of severity; but I remember perfectly a child of from three to four years old, the son of the Viceroy, whom I was attending in the very palace of Kinh-Luoc, and who recovered perfectly, in spite of the gravest symptoms. It is a custom to which the Tonkinese hold strongly, and against which I vainly strove, finding it contrary to the most elementary rules of hygiene, for with their system the patient had an absolutely insufficient air space.

'I must add that it is not only in small-pox, but in a number of other diseases, that they act in the same way.'

that case the glass must be very dark. To put it in another way, small-pox patients must be protected from the chemical rays with as much care as the photographer uses for his plates and paper. For artificial light neither electric light nor any too brilliant illuminant must be used. The globes and lamp-glasses should be of a very dark red. A candle is permissible on account of its feeble illuminating power. It may be used to examine the patient and give light while he is having his meals.

2. The treatment should be continued without the least interruption until the vesicles have completely dried up. Even a short exposure to daylight may produce suppuration, with its sequels. It is therefore absolutely necessary to nail up the curtains, to prevent the patients and nurses from allowing the light to penetrate, for it has been found that these people, tired of being in the semi-darkness, let in the light, and so reduce to nought the good results hoped for from the treatment.

3. The treatment must be commenced as soon as possible after the appearance of the rash, the nearer one gets to the suppurative period, the less chance there is of a good result.

4. It must be understood that death from small-pox will not be prevented by this treatment, especially before the suppurative period.

5. If the patients are subjected in time to this treatment, and if the rules stated above are followed out, suppuration will generally not occur, and the patients will recover without scars, or only with almost invisible cicatrices. It is to be noted that during six to eight weeks the skin remains covered

with hyperæmic or pigmented spots; at the end of this time, however, they finally disappear.

So much can be said at present on this new method of treating small-pox; the future and new experience will keep us in touch with modifications which this therapeutic procedure will probably undergo.[1]

[1] This work was completed when Dr. Œttinger published in the *Semaine médicale* of May 30, 1894, his article on the treatment of small-pox by the red-room method. His researches, conducted with the greatest care, have perfectly confirmed the statement that the chemical rays exercise an injurious influence on the course of small-pox.

Of Dr. Œttinger's eight patients three died—one because it was treated too late, the two others succumbed to the variolous infection, properly so-called. But, as Dr. Œttinger says, these deaths ought not to be attributed to the method, for it is not proposed as a 'treatment of variola,' but only as a topical treatment of the small-pox eruption.

Of the five patients who have recovered, and who were submitted to the treatment twenty-four, forty-eight and seventy-two hours after the appearance of the eruption, three had a raised temperature for six to eight days, whilst in the two others it remained normal throughout. Not one of them seemed to have true suppuration.

As to the general conclusions on the effect of the treatment. Dr. Œttinger thus expresses himself: 'We certainly have in this method a really efficacious therapeutic measure for the eruption of small-pox. It is evolved more rapidly; and if it is perhaps illusory to hope that the vesicle will be prevented from becoming a pustule, it is none the less true that in a few days the vesiculo-pustule dries up, and that not only are the horrible scars avoided, but also the accidents dependent upon suppuration are considerably diminished in frequency.'

APPENDIX (1898)

During the four years which have elapsed since the publication of this article several communications on this new therapeutic method have appeared. All confirm its very definite effects on the vesicles of small-pox. I give here a very succinct résumé of them, enumerating them in the order of their publication. Dr. Krohn,[1] cantonal physician at Saxkjobing (Denmark), has reported three cases which he had treated in this way. Not one of the patients had any suppuration, secondary fever or scars, although in one instance the treatment was begun rather late.

Dr. Mygind, cantonal physician at Naskov (Denmark), has sent me the following observation: 'I have treated twenty-two cases of small-pox (twelve variolæ veræ, and ten varioloides) by red light. One of my patients, in whom the treatment was begun only on the nineteenth day of the disease, had a severe suppurative fever, and died on the twentieth day. Another patient with semi-confluent small-pox was treated from the fifth day. The temperature rose a little, but there was no true secondary fever, and no suppuration, for on the eleventh day the temperature curve fell to the normal. Not one of the other patients, who were all treated from the onset, had any suppuration or

[1] Krohn, 'Tre Tilfaelde af Kopper, behandlede i "rodt lys"' (*Hospitalstidende*, 1893): 'On three cases of small-pox treated in red light.'

secondary fever. All left the hospital without loss of epidermic substance, but with several hyperæmic spots. Under the influence of this treatment, the course of the disease was benign and the general condition left nothing to be desired.

Dr. J. W. Moore,[1] of Dublin, described a case of small-pox, under the care of one of his colleagues, treated with red light.

There was no suppuration, and very little secondary fever, as can be seen at once from the temperature-chart which is added to his observations. Dr. Moore remarks that several times the patient spoke of the agreeable impression which the red light gave him, and of the feeling of well-being which he experienced. During the same epidemic of small-pox at the Cork Street Hospital in Dublin this method was used, and the medical officer at this hospital expressed his perfect satisfaction at the result obtained.

Dr. Peronnet[2] (Paris), in his thesis for the degree of Doctor, has published the minute clinical histories, with temperature-charts, of eight cases which he treated. (These are the cases of which Œttinger speaks.) His criticism of Juhel-Renoy's cases is especially well considered. The author says (p. 38): 'It seems to me that this contradictory result can be very easily explained. The red paper and Turkey twill curtains which M. Juhel-Renoy had placed over the windows were, perhaps, not sufficient in a case

[1] J. W. Moore, 'A Case of Small-pox and its Lessons' (*Dublin Journal of Medical Science*, December, 1894).

[2] Peronnet: 'Du traitement de la variole par la méthode de Finsen' (*Thèse*, Paris, 1897).

where thick red curtains or windows with very dark glass are necessary. *We know, moreover, that during the day the surveillance of the patients under the treatment was not very exact, and the sunlight had very little difficulty in getting into the isolation rooms.*[1] The objections which M. Juhel-Renoy has raised to this method are easily refuted by Dr. Peronnet. M. Juhel-Renoy had not experimented with sufficient care : it is enough to remark that in one case, for example, the patient was not exposed to the red light until after the commencement of suppuration and secondary fever.

Dr. Abel[2] (Bergen, Norway), cites twenty-three cases of small-pox, treated since 1893 in red light at the Small-pox Hospital at Bergen. Of these twenty-three cases eight were very severe. All the patients recovered ; suppuration did not occur at all, except in one case which was suppurating when admitted to the hospital on the tenth day of disease. Dr. Abel makes the following remarks upon this patient : 'Even in the patient admitted with full suppuration the favourable effect of the treatment was immediately visible. From the next day the fever diminished and the irritation of the pustules lessened. As on admission to the hospital the papules had suppurated, I had no opportunity of noticing the point observed in all the others, viz., an arrest in the progress of invasion of the pustules, and the localization of the suppurating process to the

[1] The italics are mine.

[2] Abel, 'Om Dr. Finsen's behandling af variola med udelukkelse af lysets Kemiske Straaler' (*Medicinsk. Revue*, August. 1897) : 'On the Finsen treatment of variola by exclusion of the chemical rays of light.'

vesicles already existing at the beginning of the treatment. This case, however, taught me to start the Finsen treatment without delay, however advanced the suppuration might be. Of all the cases described, this patient showed the most discrete vesicles, and he was the only one in whom true suppuration was present.'

As to scars, Dr. Abel thinks that he has not been so successful as other observers. A relatively great number of his patients presented superficial cutaneous changes, especially upon the forehead and nose; the scars, however, did not in any way resemble those which are commonly observed. They looked rather as if they had been produced by scratching or some accidental cause.

Dr. Abel ends by saying: 'I can only conclude from the foregoing observations that with Dr. Finsen's method we possess a treatment of small-pox which, if carefully followed out, and if the patients are submitted to it from the onset of the disease, modifies its course so powerfully that suppuration and its consequences may be abolished.'

The last communication which I know on this therapeutic method is from Dr. Hermann Backmann.[1] At his fever hospital at Koliikkomaki, since November, 1893, the author treated in all sixty-two severe cases of small-pox by the exclusion of the chemical rays.

Of the sixty-two patients three adults died, all of pneumonia, and four children (eight months to

[1] Hermann Backmann, 'On Small-pox and the Chemical Rays' (*Finska läkaresällskapets handlingar*, i., tom. xl., No. 5, May, 1895, p. 486).

Fig. 1.—Portrait of C. B., aged 48 years, taken on the 8th day of the disease. The patient was treated by red light at the Small-pox Hospital in Copenhagen from the 3rd to the 12th day of the disease. There was no suppuration. She left the Hospital on the 24th day after the taking of the photograph **without scars**, but with numerous hyperæmic spots. The temperature chart shows that there was no secondary fever.

To face p. 32

one and a half years old), of whom one died on the third day, two on the fifth, and one on the tenth day after admission to hospital.

The author says: 'The minority only of these cases arrived at the hospital before or immediately after the appearance of the rash. These cases recovered most quickly. In the majority, the treatment by the exclusion of the chemical rays could not be started until one or two days after the appearance of the rash, and the recovery was consequently postponed. Generally the suppurative period passed off quickly and easily, the vesicles dried up sooner than usual, and left no scar at all. The average time in the hospital in sixty-two cases was 19·5 days, although several subjects remained longer than was necessary.'

These favourable results in the treatment of small-pox by the exclusion of the chemical rays have prompted the author to extend it to other acute exanthems (especially scarlet fever and measles), and he has constantly found the method active, the course of the disease becoming milder and shorter.

In order that nothing shall be omitted, I will cite an article of Dr. Moir[1] against this treatment which appeared in the *Lancet*. Not only has Dr. Moir not tried this method, but he seems also to be ignorant both of the scientific interpretation which I have been able to give of the phenomena and of the experimental proofs. He has, nevertheless, discountenanced it, relying upon superficial theo-

[1] John Moir, 'Treatment of Small-pox by Exclusion of the Chemical Rays of Light' (*Lancet*, September 29, 1894, p. 739).

retical considerations. He concludes by exclaiming: 'Light! light! More light!'

If we now seek to state precisely the results of all these researches, we see that fourteen physicians have given pronouncements upon my method. Dr. Moir alone has opposed without having tried it at all. There remains M. Juhel-Renoy, who, according to Dr. Peronnet, has put it into operation in such a manner that the value of his results are found to be impaired. *All the other observers* agree in recognising the happy results of this method of treatment. This may seem the more remarkable, as this measure might at first appear strange, and for this reason to be received with complete scepticism. Their agreement is only the more significant.

From the statistical point of view we notice that the method has shown itself to be really excellent. Out of a total of 140 to 150 cases of small-pox, some very severe ones, chosen specially for this trial, which have been thus treated, it can be affirmed that in one case only, that of Dr. Benckert, was the method inefficacious.

In conclusion, the treatment which I have described seems to have proved its value, and there is every reason to give it the place that it deserves in therapeutics, a place which it is at present still far from having obtained, doubtless owing to its strangeness and unintelligibility. In reality, its scientific basis is much better and more solid than that of many other methods of medical treatment.

At the end of my first article I enunciated the principles of the treatment and the conditions necessary for its success, adding that the future

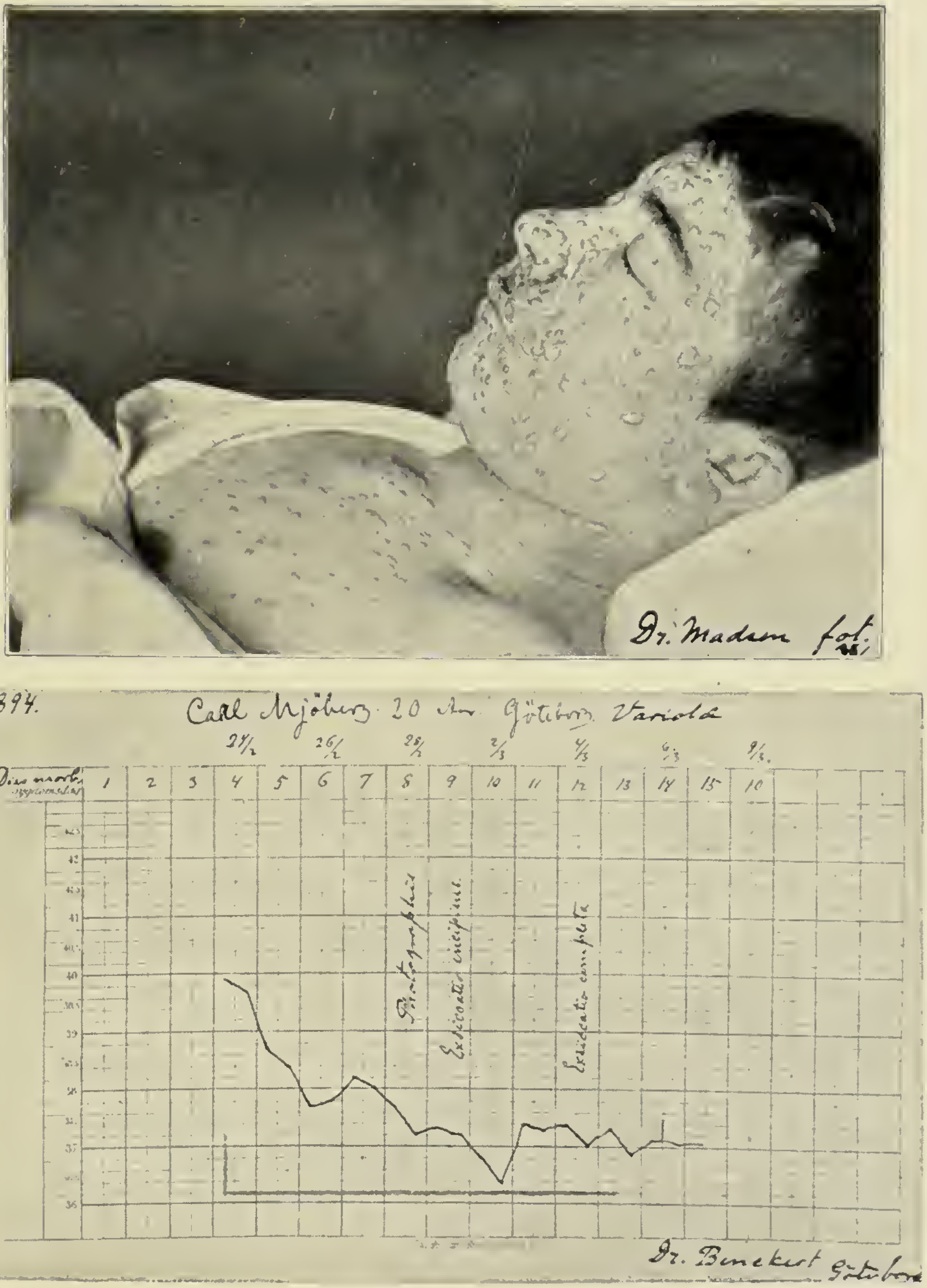

FIG. 2.—Portrait of C. M., aged 20 years, on the 8th day of the disease. He was treated by red light at the Small-pox Hospital in Gothenburg from the 4th to the 13th day of the disease. No suppuration, no secondary fever. On the 23rd day after his admission into Hospital he was **free from scars.**

To face p. 34

and new researches would probably bring some changes.

Four years have passed since the publication of my first paper, and in spite of further experience it seems to me hardly necessary to change anything that I have said. Perhaps one might be less severe in the practice. It is doubtless useless for the red colour of the curtains and window-panes to be very dark. A lighter colour will be more agreeable to the patients, and increase their comfort and that of those in charge of them.[1] Experience has shown that the therapeutic results are still better than I anticipated ; above all, it has been seen that the method is favourable not only in the case of patients who are treated a little while before the onset of suppuration, but even in its earliest stage.

One point remains still to be discussed : Can the sojourn in the red light do harm ? Practically the answer is implied in the preceding observations. No observer has noticed any inconvenience. Theoretically, one could not say that it was likely to be harmful to subject patients to the exclusion of the chemical rays for the short time which is demanded by the treatment. (See the following article.) On all these points very little is known with regard to man. In every case, if a sojourn of from eight to

[1] In a room less dark the results will not perhaps be so striking. It appears that the observers who have proceeded rigorously have almost completely avoided the secondary fever. On the other hand, a slight elevation of the temperature will be preferable to a too absolute darkness ; those who attend upon the patients will derive great advantages from it. Practically, one should insist that the red should be sufficiently dark to avoid suppuration. A series of comparative researches would alone fix a sufficiently dark red.

fifteen days in red light can be harmful, this defect is compensated, and more than compensated, by the advantages which are derived from it. If it is desirable, however, to obviate a supposed weakness, nothing prevents the employment of the ordinary stimulants.

The three portraits accompanying this article are taken from photographs made by Dr. Alfred Madsen. I here tender him my thanks for them. I must at the same time thank Professor Feilberg[1] and M. Benckert,[2] chief physician to the wards in which the patients were treated. My explanations are based on the clinical observations of these two colleagues.

[1] C. Feilberg, 'Behandling af Kopper med Udelukkelse af Dagslysets Kemiske Straaler' (*Hospitalstidende*, July 4, 1894): 'Treatment of small-pox by the exclusion of the chemical rays of light.'

[2] Henric Benckert, 'Om Smitt Koppers behandling med Uteslutande af lijusets Kemiske Straaler' (*Hygcia*, tom. 56, 1894, extract): 'On the treatment of small-pox by the exclusion of chemical rays of light.'

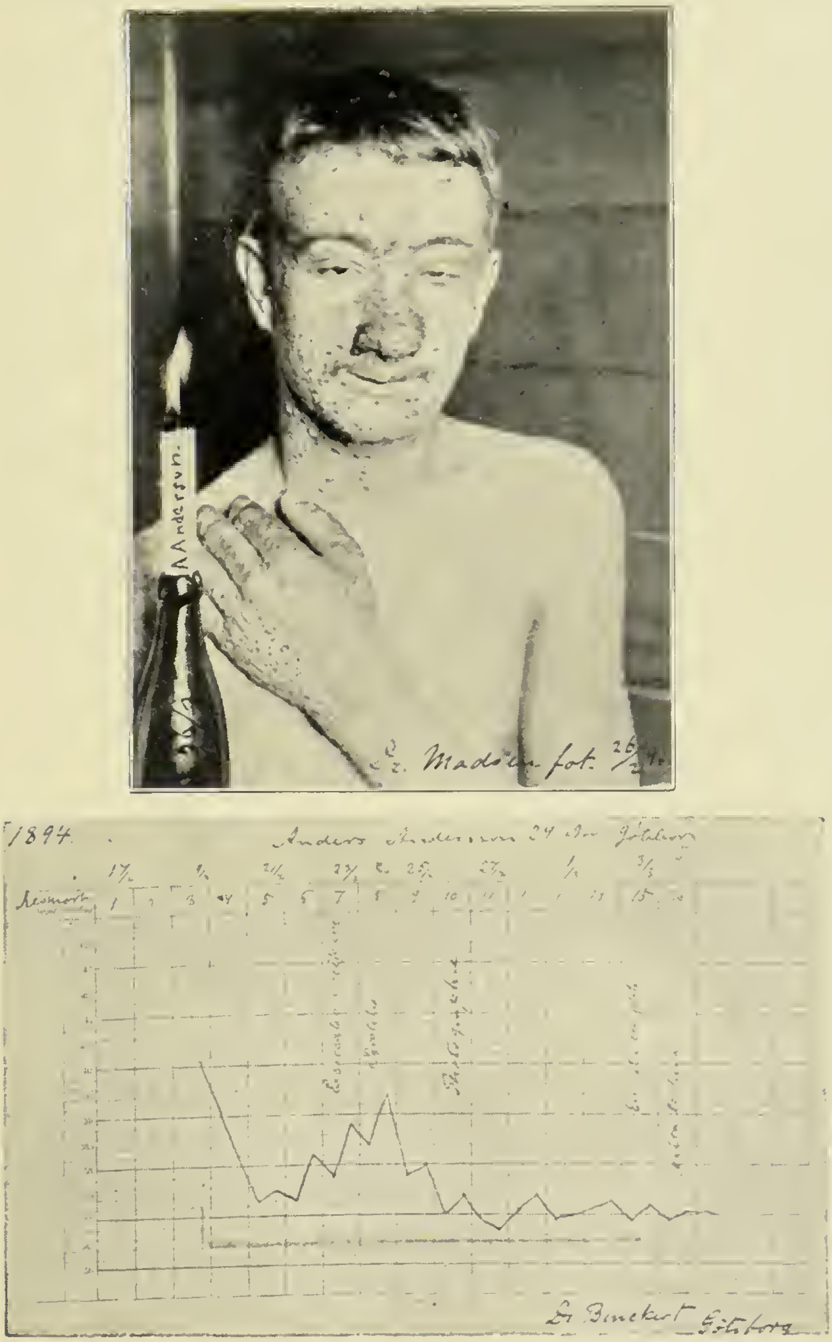

Fig 3.—Portrait of Andreas A., 24 years old, on the 10th day of the disease. He was treated with red light from the 3rd to the 15th day of his illness in the Small-pox Hospital at Gothenburg. No suppuration. He left after 22 days' detention in the wards. **On the tip of the nose there were a few insignificant scars, but not one on the whole of the face.** The elevation of temperature on the 8th day was apparently due to a simultaneous inflammation of the right parotid.

To face p. 36

LIGHT AS A STIMULANT

(1895)

In observations upon the development of the eggs of the frog, it is noticed that towards the end of fœtal life the oblong embryo, coiled up on one side moves intermittently in such a manner that it turns instantaneously to the opposite side. I have been able to determine that these movements increase considerably under the influence of direct sunlight. The same observation can be made upon the eggs of the salamander, the fœtus of which, curved into the shape of a ring, undergoes movements which are still more marked.

The following are the experiments which I devised to analyze this phenomenon and to study the relationship between the motility and monochromatic light. Four eggs of the salamander (*Triton cristatus*), almost at full term, were placed in a flat dish filled with water, and exposed to direct sunlight. By the interposition of coloured glasses I was able to observe the special action of the different rays of the spectrum, and by interposing the hand I produced a darkness relatively sufficient for me to consider it as shade.

The rapidity of the movements provoked was such

that I was obliged to share the work with an assistant. Each of us watched two eggs, thus taking count of four, so that the enumeration had some chance of being exact.

The following table of numbers was obtained under these conditions :

Number of Eggs.	Quality of Light.	Duration of Experiment in Minutes.	Number of Movements.	
4	Blue	3	8	
4	Shade	6	0	
4	Red	3	0	
4	Blue	3	4	
4	Red	6	3	
4	Blue	6	26	
4	Yellow	2	0	
4	Shade	5	1	
4	Yellow	7	0	Temp. 22° C.
4	Green	7	2	
4	Colourless glass	4	6	

The absence of the sun necessitated our interrupting our experiments, which were resumed two days later with the same eggs :

Number of Eggs.	Light.	Minutes.	Number of Movements.	
4	Colourless glass	5	12	
4	Blue	4	9	
4	Red	5	2	
4	Blue	3	7	Temp. 22° C.
4	Shade	10	0	
4	Green	10	6	
4	Blue	5	15	

The experiments made in the above order had to be stopped owing to an accident : one of the fœtuses, becoming detached from the egg, swam freely.

To exclude variations due to heat from the phenomena observed, I took care to maintain a constant temperature by a current of fresh water.

The results are thus clear and definite. It is seen at once with what rapidity the movements are produced under the influence of blue light. By the

addition of the result of isolated experiments the following figures are obtained :

Light.	Minutes.	Number of Movements.
Shade	21	1
Red	14	5
Yellow	29	0
Green	17	8
Blue	24	69
Colourless glass	9	18

A more correct idea will be obtained by taking the mean times and the proportional number of movements :

Light.	Minutes.	Number of Movements.
Shade	16	1
Red	16	6
Yellow	16	0
Green	16	8
Blue	16	46
Colourless glass	16	32

These facts show (1) that light possesses the very remarkable faculty of provoking movements in the fœtuses ; and (2) that this faculty must be especially attributed to the violet rays.

It would be premature to draw more definite conclusions, but we may here remark a curious peculiarity, viz., that whilst the blue rays provoke the greatest number of movements, white light alone causes a number sensibly less. But the duration of the observations on these radiations being curtailed. it may be that this difference, otherwise slight, is only accidental.

I then undertook the following experiment upon more developed animals. Three salamanders—one a day and a night old, and two others born an hour before the experiment—were placed in a flat dish filled with water. These little animals, about a

centimetre long, remained motionless in the water, like pike when they 'sleep.' They moved in a straight line, and very rapidly, by jerks, until they came to rest. The dish was put in the shade, and I placed a parabolic mirror (Liebreich's ophthalmoscope) in such a position that I could illuminate each of the animals with a beam of light.

Under the influence of the light the salamanders, after an exposure of some seconds, darted precipitately, and then stopped. This phenomenon was so constant that it was even possible to direct the orientation of the movements by the play of the luminous pencil. In the absence of all luminous influence the salamanders remained motionless, and hardly ever moved spontaneously.

The dish was then placed half in the shade and half in the sun. The salamanders moved excitedly about, in an aimless manner, until the moment when they entered the shade, when they became motionless; the displacement of the light in the opposite direction provoked an opposite movement of the animals. Under all circumstances they fled from the light. Pure red, yellow, and green rays did not influence the salamanders; blue light alone provoked a reaction as rapid as compound light.

These experiments have been sufficiently numerous to permit the statement that the phenomenon is constant. A new series of observations showed this constancy by numerical expressions.

The dish with the three salamanders was exposed to full sunlight, and the radiations were analyzed by the interposition of coloured glasses. Under these conditions the time of reaction was variable,

and, naturally, a little different for each of the three animals experimented upon. In the following table we have only noted the time at which any one of the three salamanders darted in the water. These experiments were made in the order indicated, and without interruption :

Young Animals.	Duration of Experiment in Minutes.	Time of Reaction in Seconds.		
		1	2	3
Blue	—	20	21	35
Shade	2	50	65	0
Yellow	3	0	0	0
Blue	—	10	12	20
Red	3	0	0	0
Green	2	0	0	0
Blue	—	7	7	56
Yellow	3	0	0	0
Red	3	0	0	0
Green	3	0	0	0
Blue	—	20	25	30
Red	—	25	60	120
Colourless ...	—	10	33	42
Red	2½	0	0	0
Colourless ...	—	15	15	15
Red	1½	0	0	0
Blue	—	20	41	42
Red	2	0	0	0
Without glass...	—	13	15	17

This table confirms in a clear manner the pre-

ceding statements. The mean times of the reactions are:

To direct sunlight (three reactions), fifteen seconds.

With colourless glass (six reactions), twenty-two seconds.

In blue light (fifteen reactions), twenty-four seconds.

In one of our experiments, red light, like shade, provoked reactions which could only be regarded as accidental.

An exposure to green light for five minutes, and to yellow light for six minutes, were insufficient to cause the least movement. This is a circumstance the more remarkable because these rays produce a great impression on the sense of sight. *A priori*, we should have been led to attribute to them supreme importance. We have been able to make the same observations upon the movements of the fœtus, viz., that yellow light has very little influence. (See, however, the percentage table later.)

To determine how far the temperature of the water influenced the course of these phenomena, five young salamanders, from one to three hours old, were placed in a dish filled with water at a temperature of 18 C. By the addition of warm water, the temperature was gradually raised, in the course of ten minutes, to 30°. During this time the salamanders remained motionless; one only moved at 20°, and two others at 30°.

By the slow addition of cold water the temperature was then lowered in ten minutes to 20°. At 21° one animal alone reacted, the others did not

seem to be affected, in spite of the relative strength of the current of water which moved their tails.

It thus appears obvious that the direct influence of the temperature of the flowing medium may practically be neglected within limits—certainly from 18° to 30°—and that the rarity of the movements, in the absence of excitation by light, is sufficient to eliminate the effect of heat.

It must be understood that the value of these last researches depends in part upon the value attributed to young salamanders as subjects for experiment. I believe that their spontaneity and their immaturity could only be advantageous, for when still less developed they hardly move at all without a violent external cause, such as the oscillation of the water under the influence of shock.

Two points, often enough neglected by authors, still remain to be elucidated, viz., in the first place, the strength of the light, and, secondly, the condition of the coloured glass with regard to monochroism.

I made experiments at Copenhagen, at the beginning of June, between noon and three o'clock, with a clear sky, veiled at times by light clouds. But at the moment when the intensity of the sun was thus diminished, I stopped the experiments or I took the opportunity to observe the effects of shade.

The quality of the glass is of greater importance. I have only employed the four colours, red, yellow, green and blue, because I could not procure glass of other colours sufficiently pure. One of my violet glasses allowed all the rays except the violet to pass through.

I was able to determine by the spectroscope that the red glass allowed the red rays only to pass, while the yellow glass (rather orange) was traversed by red, yellow and green rays, and the green glass by red and blue rays, the intermediate field remaining green. The blue glass allowed blue and violet rays to pass, and also, very feebly, some red and green-blue rays.

Astonishing as they appear, these defects of coloured glasses are none the less common. That this fact, however, did not introduce a sufficient cause of error, I can easily demonstrate by the action of a scale of colours. As a matter of fact, with red glass giving pure red rays, the effect is hardly more marked than with shade. The action of yellow glass[1] (red rays + green) is still less. Green glass (*i.e.*, the same rays + some very strong green rays + some blue and very few violet) gives a better result. And, lastly, blue glass (*i.e.*, the other weak rays, with the addition of a large number of violet rays) gives a very strong reaction, especially attributable to the violet.

The officials of the physiological laboratory of the University kindly determined the percentage of absorption of the light of these glasses by means of the Vierordt-Kruss apparatus. The results are as follows:

Red Glass.—Traversed by the red rays only.

C allows only 19 per cent. of the incident light to pass through.

---

[1] This glass allowed relatively few yellow rays (10 per cent.) to pass; it was therefore necessary always to remember that 10 per cent. of the rays of the sun give a stronger impression than 19 per cent. of the red, or 26 per cent. of the violet, for example.

Orange Glass.—The red, yellow and green rays pass, but not the blue and violet.

B allows 15 per cent. of the incident light to pass through.
D_4 E allows 10 per cent. of the incident light to pass through.
D_{77} E ,, 6 ,, ,, ,, ,, ,,

Green Glass.—The green rays + some blue and violet pass, and also a very small amount of the red and yellow rays.

C. The light does not pass through.
D_{77} E allows 43 per cent. of the incident light to pass through.
F_{15} G ,, 11 ,, ,, ,, ,, ,,
G ,, 5 ,, ,, ,, ,, ,,

Blue Glass.—A narrow red band is seen at B, a rather large band at D_{40}E; the rest of the spectrum is black as far as E_{38}F, and then clear.

B allows 17 per cent. of the incident light to pass through.
D_{40} E allows about 5 per cent. of the incident light to pass through.
F_{15} G allows 22 per cent. of the incident light to pass through.
G ,, 26 ,, ,, ,, ,, ,,

The effect of excitation by light can be observed remarkably well in tadpoles kept in the shade for some weeks. Every time that they are exposed to daylight when the water is changed, they swim with a vivacity which I have never observed in other tadpoles.

An experiment which was made before my researches upon the salamanders is also confirmatory. I had raised from the eggs under light of different colours a certain number of tadpoles, which, however, received daylight every twenty-four hours, when the water of their aquarium was changed. I soon noticed that the tadpoles living in red light were very active, while those which were in blue light

were rather indolent. The very simple explanation of this phenomenon did not then occur to me, as my attention was not directed to these considerations. The tadpoles accustomed to blue light were not excited by the sunlight, while those which had only received red rays were very excited, because they were unaccustomed to it.

Certain researches of Schenck[1] exactly confirm my own, though the author draws almost exactly opposite conclusions from them. He says that tadpoles brought up from the embryonic period under red glass are more lively than those raised under blue glass, and that if the glasses are reversed, the corresponding change takes place in five to six days, and the difference is equalized after a sojourn in ordinary daylight of some days' duration. Schenck concluded from this that red light enlivens the animals, and that blue light stuns them. M. Schenck says at the same time that he brought up his tadpoles in opaque earthen vessels with lids of coloured glass, which he raised when he wished to observe the activity of these animals. His observations thus not only confirm mine, but they add to them a new interest, since they determine the relationship of the activity of the chemical rays, and the rapidity with which the faculty of reacting to them may change.

Graber,[2] by carrying out very many experiments

[1] Schenck, 'Zur Lehre über den Einfluss der Farbe auf das Entwicklungsleben der Thiere' (*Mittheilungen aus dem embryologischen Institut der Universität in Wien*, Bd. I., S. 265).

[2] Graber, 'Grundlinien zur Erforschung des Helligkeits-und Farbensinnes der Thiere' (quoted by Hammer: 'Einfluss des Lichtes auf die Haut,' 1891, p. 10).

on the action of white and coloured light on the skin of blind salamanders, cockroaches, and entire and decapitated worms, has demonstrated that these animals can distinguish by their integument red from blue. They sought the red colour and avoided the blue, and that independently of the heat. He is of opinion that these animals possess a certain photodermic irritability.

Dubois[1] has made experiments with the proteus, and has shown that this batrachian prefers red light to blue-violet light. His researches on the other colours, however, are at fault, in the matter which I have mentioned above. He does not tell us anything of the nature of the glasses, which, to judge from his results, seem to have been defective enough.

I have myself made some experiments with the earthworm (*lumbricus*). I placed twenty of these worms in an oblong box,[2] distributing them about. I made a lid for the box with a series of glasses of different colours, arranged in the order of the spectrum, red, yellow, green, blue.[3] At the end of some minutes all the worms had moved towards the red glass, and I was able to control this observation by turning the cover in such a way that the blue replaced the red, when the worms were again found under the red glass. This experiment was frequently repeated, and always with the same result, whether

[1] Dubois, 'Sur la perception des radiations lumineuses par les protées aveugles des grottes de la Carniole' (*Comptes rendus*, cx., p. 360).

[2] The box was about 25 centimetres long and 7 centimetres high.

[3] For these researches and for those that follow I used the same quality of glass which was studied above.

with diffuse daylight or sunlight. Sometimes, however, the annelids remained under the green, but these instances could only be regarded as accidental.

The time necessary for them to go away from the blue light was variable, and depended upon the intensity of the light. As a rule, half an hour to an hour was sufficient. Under the red glass the worms usually remained quiet in a heap, but when the cover was turned, and they found themselves under the influence of the blue light, they began to move and crawl about in every direction at the end of from half a minute to a minute. They were in a disturbed state for some time before going quite out of the blue part. By the following experiment, it was possible to observe still better the extraordinary influence of light, and particularly of the chemical rays, on the worm :

I had a certain number of worms to feed my salamanders, but as the result of an accident, several died, and the rest were very weak. To make use of as many as possible, I tried to revive them in several ways, for instance, by moistening them, but without any appreciable result. I then exposed them to direct sunlight, and three or four of them began to react and recovered.

Like the earthworm, it is known that the earwig (*forficula*) likes to keep hidden during the daytime. To learn if this animal reacted to light, I placed twenty or thirty in the box described. The result was identical, perhaps even still more striking, the movements of the earwigs being more rapid. When, on turning the cover, the blue light fell upon the

animals, their extraordinary evolutions were curious to watch. Their antennæ began to vibrate, the animals at once became restless, running to all sides, until they finally came to rest under the red glass. The experiments were frequently repeated, and at last the adults seemed to understand the situation, for after several changes of the light, they no longer mistook the road, but made off without hesitation towards the red light.

It is a commonly observed fact that the earwig and the earthworm like to burrow in corners and little holes; as the corners of our box were only illuminated by red and blue light, we could only conclude from this experiment the affinity of these animals for these colours.

Some woodlice (*oniscus*) and beetles (*pterostichus*) were placed in the same box, and showed almost identical phenomena.

All these animals, the earthworms, earwigs, woodlice and beetles, are, as we have seen, very sensitive to light; they avoid it and hide away in consequence of the strong excitation of the chemical rays. To observe the manner in which animals which like light comported themselves, I placed eleven butterflies (*pieris*) in a little larger oblong box, the lid of which was half of red and half of blue glass. The box was then exposed to the direct action of sunlight. Immediately after their imprisonment, all the butterflies beat their wings violently, but at the end of some moments those which received the light through the red glass remained for the most part at rest, while in the blue part they were incessantly moving. Later, when the sun ceased, the butterflies

influenced by the blue light became quiet, and an hour afterwards they were disposed in such a manner that ten butterflies were in the blue zone and only one in the red. I inverted the colours by turning the cover, and at the end of an hour eight butterflies were found bathed in the blue light and three remained in the red. We could not get butterflies to continue the experiments, which seemed, however, to indicate the preference of these insects for the chemical rays, and the influence of these radiations on their movements.

My experiments on twenty or thirty meat flies (*Musca vomitoria*) did not give such positive results. For these researches the arrangement was modified in the following way. One of the sides of the box was made of three glasses, successively red, orange, and blue, while the opposite side was of colourless glass. This box was placed at a window, the coloured side towards the light. The flies were observed for about a month. During the whole day the animals moved about at hazard in their prison, the different colours not appearing to have the least influence upon them.[1] I believe that this depended upon the great number and the variety of their

[1] Perhaps this point is not absolutely correct. I have since seen (*Dublin Journal of Medical Science*, December, 1894) that at the Small-pox Hospital in Dublin the absence of flies in the rooms illuminated with red light was noticed. It is, however, difficult to know if the flies were really absent, or whether they only kept quiet. My observations agree but imperfectly with this observation. One would, however, believe that the phenomenon may vary according as one observed meat flies and ordinary flies; and perhaps my box, 32 centimetres long and 4 centimetres high and broad, was too small, and this might diminish considerably the influence of light, especially on animals of a lively nature.

motives of movement. Only towards evening they collected behind the red glass, to sleep during the night. This fact was absolutely constant; very rarely one alone remained under the blue glass and some under the orange.

To attract the flies I placed several pieces of sugar behind the blue glass, but without success ; they none the less continued to sleep in the red zone as before. By the interposition of some opaque plates before the blue glass, I at length made one of the extremities of the box comparatively dark, while the rest was illuminated. The next evening all the flies except one slept in the darkened part, and this happened every time the blue glass was darkened. We can deduce from this that flies like to sleep in places where the excitation of light is the most feeble. Although the interpretation of this fact may be of little importance in itself, it may be considered that their choice is determined by instinct; properly speaking, it is hardly a question of true choice : the animals rest best where they are the least excited. For it was observed that at dusk the flies, so busy during the day, became quiet, and one after the other settled in the red or black part ; it seemed that there they yielded the more easily to sleep. Whatever it may be, whatever explanation is suggested, this observation only confirms the results of my former experiments.

The evident result of these researches is that the action of the chemical rays (blue-violet) on these animals, compared with that of the heat rays (red), and light rays (yellow), is very considerable. More than that, we find in it a demonstration of the

extreme influence of the chemical rays upon the organism. It is doubtless a very complex phenomenon, due no doubt to molecular combinations of the protoplasm in the cells. Broadly, we shall define the aspect better by looking upon it as *an excitation of the nervous system.*

This action is, we have seen, *so pronounced that in some cases it may provoke well-marked reflex actions* (in the fœtus), *and in other instances produce very powerful and special reactions* (in photophobic and etiolated animals). The biological importance of these rays, it is certain, must be considerable, and it can be said that they are truly *promoters of life and energy.*

It has been seen that in some of my experiments I have made use of animals reacting easily to light; in other instances I tried the effect of an intense light—or, what comes to the same thing, of ordinary daylight—on animals wholly or partially etiolated. The reactions in them have only been the more marked.

But under ordinary natural conditions the influence of the chemical rays is seen with difficulty, *their action not directly striking the observer. However, we may well suppose*—especially if we compare these researches with what we know otherwise of the effects of light—*that this action is constant and of daily occurrence, and must thus be of great biological importance.*

By my previous remarks, I have desired to draw attention to the *chemical power* of light. This power—theoretically parallel to two other forms of solar energy, *heat* and *light*—no doubt constitutes a

means of action too much neglected in medicine. We know that the chemical rays bring to the body which absorbs them a certain energy transformed in different ways, and we come to see that the most special transformation of this energy, from the biological point of view, seems to be an excitation of the nervous system,[1] which doubtless influences, secondarily, all the vital functions.

Although my experiments are only in relation to the inferior animals, there is, however, every reason to believe that an identical or similar influence is exercised by the chemical force upon the higher animals and upon man. These are questions to which I propose to return later.[2]

There is, then, every reason to profit by this force in nature, in medicine, and hygiene. But before thinking of using it, it would be necessary at first to carefully study the effects. The treatment of small-pox by the exclusion of the chemical rays permits the belief that this fertile path has already been entered.

It may seem curious that one has commenced with the *harmful* effect, since there is reason to expect a much greater benefit from the *favourable* action of this force. The treatment by exclusion was the result of a theory the justice of which is now demonstrated, while the empirical proofs of treatment by exposure to the chemical rays are

[1] It is understood that I do not wish to say that the chemical rays do not possess other important biological functions.

[2] In this little memoir my intention has been to discuss no other forms of light influence but the chemical. I have tried to give some idea of it by the help of a limited number of observations; this work is, therefore, only a fragment.

still wanting. Nevertheless, I believe implicitly that in the future use will be made of this new therapeutic agent,[1] and the proof experiment once made, it will be easy to carry it out practically under the form of light baths;[2] and, lastly, to determine whether they are to be blue or violet, the variations in their strength and duration, and whether natural or artificial.

After this little medical digression, I will set out what seems to me to be especially established by these experiments.

We all know the very special effect of direct sunlight on all organisms. Sudden transitions from a cloudy to a clear sky make us feel it much

[1] Since this was written I have invented the treatment of cutaneous diseases of bacterial origin by concentrated chemical rays (see the following chapter).

[2] Light baths in some fashion are not absolutely new or unknown. They were already used in antiquity (sun baths), and later, in different places and at different epochs, they have been employed with advantage. Recently I saw that at Chicago the use of 'electric-light baths' had been begun, and baths of blue light are not unknown. An American, General Pleasanton, used blue light in different ways—to cultivate vines and other plants, for the rearing of animals, and as baths for the sick. His light was not, however, pure blue; for every blue square he had three clear ones. Pleasanton published a book on his method, 'The Influence of the Blue Ray of the Sunlight and of the Blue Colour of the Sky in developing Animal and Vegetable Life, in arresting Disease, and in restoring Health in Acute and Chronic Disorders to Human and Domestic Animals'; Philadelphia, 1877. This author's attention was drawn to this question by the consideration that since the sky is blue, this colour must be of great importance to animals and plants. He discussed also the remarkable chemical qualities of the blue rays. He thus approached the truth; but his faulty experiments, and, above all, his tendency to look upon blue light as a universal panacea—the very title of his book indicates this—have not contributed to show the value of a biological agent whose importance is beyond discussion. The General's book, printed on blue paper and bound in blue, makes one think, however favourably disposed one might be, that its contents could hardly fail to be 'coloured' also.

more than continuous sun. If the sky has been overcast for part of a day, and the sun suddenly comes out, it is as if Nature had been brought to life. The insects fly and hum gaily; the reptiles bask in the bright sunlight; the birds chirp; and we ourselves get a feeling of well-being and of fulness of life.

This somewhat indefinable effect is none the less very marked. One might say that light is an 'exciter of life,' in the sense that it excites living activity and provokes movement. I believe I am right in saying that this quality has hitherto been attributed to the 'psychical' action of light and to that of heat. It seems to me that both my positive and my negative experiments have sufficiently shown that we ought to refer the greater part to the chemical rays, which possess a stimulating influence on the lower animals.

APPENDIX

(1899)

The above researches, made in the spring and summer of 1894, and published in February, 1895, are only the fragment of a series of observations which other work obliged me to interrupt, without my being able to take them up again.

In the spring of 1895 I had occasion to observe on the fœtus of the frog very strong secondary effects of light. This observation does not alter in any particular the principal results of my former researches; it only forms a necessary supplement to them. Besides this, the experiments seem to indicate that the essential exciting action is specially dependent upon the ultra-violet rays.

This secondary influence of light, which is also shown in other effects of the chemical rays on the living organism,[1] attracted my attention in the following research.

In a little flat dish of white porcelain, full of water, I placed three fœtuses of the common frog. These fœtuses were just being born; under my eyes they were detached some moments afterwards from the yolk of the egg. The observation was made at Copenhagen at the beginning of May, at mid-day, in bright sunlight. The arrangement was similar to that which I have described in my studies on the

[1] Besides this, a secondary effect of similar character is also seen in many inorganic compounds. *Cf.* the observation of Bunsen and Roscoe concerning the action of light on chlorine and hydrogen.

fœtus of the salamander; but to obtain uniform results, the duration of the exposure to the different colours was the same—three minutes. The movements of the fœtuses of the frog at this age are identical with those observed when they are still in the egg, so that one can count them in the same manner.

The following table indicates the results of these experiments which were made without interruption and in the order indicated:

Number of Fœtuses.	Light.	Duration of Experiment in Minutes.	Number of Movements.
3	Shade	3	20
3	Red	3	19
3	Shade	3	13
3	Yellow	3	38
3	Shade	3	13
3	Green	3	3
3	Blue	3	57
3	Shade	3	28
3	Clear glass	3	60
3	Shade	3	28
3	Without glass	3	59
3	Shade	3	51

The fœtuses were then put in the shade, and five hours later I again counted their movements twice, each count lasting three minutes. During the first three minutes I observed only one propulsion, and during the following three minutes I could only make out three.[1]

This table, it will be seen, ends with a very considerable number of movements in the shade immediately after an exposure to the direct sunlight (without glass). I should observe that it is necessary to consider direct sunlight as slightly different from

[1] The glasses of these experiments were those used in the former researches, if I remember rightly. The interest of the table, however, does not depend upon the colours.

that transmitted by clear glass. The first contains many more ultra-violet rays than the second, the glass absorbing them in great part. Moreover, this table shows us an increase in the number of movements in the shade in proportion to the repetition of the experiments. I could not help suspecting a cause of error in the production of these numerous movements in the shade, and I immediately started control experiments.

I took three more fœtuses of the frog like those which I had just used, and placed them in the same manner in a similar dish. I then began to count the movements in the shade during five minutes; then I exposed them to direct sunlight for five minutes. I again put them in the shade, noting the number of movements during five consecutive minutes. These are the results obtained:

Number of Fœtuses.	Light.	Duration of Experiment in Minutes.	Number of Movements.
3	Shade	5	1
3	Direct sunlight	5	45
3	Shade	5	107
3	Shade	5	112
3	Shade	5	75
3	Shade	5	30
3	Shade	5	32
3	Shade	5	29
3	Shade	5	26
3	Shade	5	22
3	Shade	5	28

Thirty-five minutes afterwards I again counted the movements twice during five minutes; during the first five minutes one single movement was produced, and during the following five a single fœtus made ten very feeble spasmodic movements following each other without interruption. Six hours later I again counted the movements of the same animals

twice over during five minutes; during the first five minutes there were two movements, and during the following five sixteen.

This table has no need of commentary; it shows in a striking manner that the integral effect of the excitation by the chemical rays only shows itself at the end of a certain time, and that it may even have its maximum after the cessation of the cause of the excitation. This field offers opportunities for new researches. I should add that during the five minutes of exposure to the light I was struck with the progressive increase in the number of movements which were always more considerable at the end of the five minutes. This table shows still better than the others to what point the excitation produced by the chemical rays may be accentuated.

In continuation of what I wrote in the preceding article—now four years ago—on a probable application of the chemical rays as a method of treatment in medicine, I may add the following remarks: In the first place, I must call attention to the fact that I have myself since put into operation a local treatment for certain skin diseases by the chemical rays in a concentrated form. (See the following paper, p. 63). But this was not in my mind when I wrote the above memoir, for at that time I was thinking of a general treatment in the form of light baths—that is, the exposure of the whole body to the chemical rays of light. I have, however, worked the matter out, but until now have published nothing upon it, as my researches in this connection have not yet passed the experimental stage. In the meanwhile

incandescent electric-light baths, of American origin, have recently, especially in Germany, come into somewhat general use. In certain quarters there has been a good deal of charlatanism in connection with these baths, which are said to be based upon my researches into the physiological influence of light, and my name has been used in a way which could not fail to meet with my disapproval. On these grounds I have felt compelled to make some detailed remarks upon these baths.

As can be seen from my researches and my exposition of them, it is the most refrangible rays of the spectrum, the so-called chemical rays, to which, so far as our knowledge goes, we owe the special influence of light. The influence of light as a bactericide, its power to cause inflammation and pigmentation of the skin, as well as its stimulating action, are connected with the chemical rays. If it is desired to use these properties of light in therapeutics, it follows that a kind of light in which there is a suitable proportion of these rays must be applied. It is well known that in the commonly-described electric-light baths (Kellogg's baths), incandescent lamps are used; but the light from these lamps contains hardly any chemical rays, certainly not nearly so many as there are in ordinary diffuse daylight. It is therefore a very great mistake to maintain that these light baths possess the influence which I have mentioned above. It is impossible to assume that they act in any other way than by the heat-rays which the lamps give off. They are simply diaphoretic baths, in which the heat is obtained by the electric lamps, instead of by warm air or

vapour.[1] The inventor of these baths, Dr. E. Kellogg[2] himself, does not assign to them any other qualities; he has not attributed to them in the least the chemical influence possessed by light. When these baths were introduced into Europe, it was found that it would be a recommendation to ascribe to them the possession of the particular properties of light. There is, moreover, no reason to miscall these baths 'light baths,' for as diaphoretic agents they appear to be of great service.

Proper light baths, chemical light baths, such as I have proposed and actually put into practice, are totally different in their action from the incandescent light baths; they are cold, and cause a very marked effect upon the skin, and this effect upon the skin is that to which I attach the greatest importance. (The stimulant action is so difficult to estimate and so uncertain in man that it is impossible to determine it.) Recently I have made various researches upon the influence of the chemical rays upon the skin,[3] and have proved that the dilatation of the capillaries and bloodvessels of the integument produced by the light is not an exclusively acute phenomenon, but actually of long duration, and that the treatment of the skin by light, by causing a dilatation of the vessels and a more active blood-supply, probably promotes a better nutrition of the skin and a greater functional activity. My light

[1] As the incandescent lamps have recently been replaced by very small and weak arc-lights, there may perhaps be some, but hardly very much, influence.

[2] Kellogg, 'Das electrische Lichtbad' (*Aertzl. Monatsschr.*, No. 7, July, 1899).

[3] Finsen, 'Neue Untersuchungen über die Einwirkung des Lichtes auf die Haut' (*Mittheilungen aus Finsen's Medicinischem Lys-institut*, i., Copenhagen, 1899, p. 6).

baths are arranged in the following manner: I sometimes use sunlight and sometimes electric light. In the sunlight baths the patients walk about naked in a courtyard, in which everything possible is done to maintain a low temperature, so that there shall be no sweating. By a frequent sprinkling of water in the yard, or, if necessary, by douches, it is possible to get sun baths of moderate temperature. (These sun baths correspond as nearly as possible to Rikli's 'light and air' baths, but differ in their effects from the hot sun baths (*Schwitz-bäder*) of the 'Naturärzte.' My electric-light bath consists of a circular room, in the middle of which two gigantic arc-lights of 100 ampères are suspended about six feet from the floor. By numerous radiating partitions bath-chambers are formed, in which the patients lie naked upon couches. The temperature in these baths is so low that artificial heat has to be applied to prevent the patients being chilled, and the chemical influence upon the skin is just as great as with strong sunlight. These baths excite a pleasant sensation of slight tingling and heat in the skin. Individual differences in the sensibility of the integument are manifest: some people get a well-marked erythema at the end of a sitting of only ten minutes' duration, while others can bear the same light for hours together without the skin being more than slightly reddened. I will not enter here upon the indications for these light baths, nor upon a detailed description of them. It is my intention only to show the difference between the kind of electric-light baths which are actually heat baths and the electric-light baths which are intended to produce a true light effect—a chemical effect.

THE TREATMENT OF LUPUS VULGARIS BY CONCENTRATED CHEMICAL RAYS

(1897)

The fact that light possesses a powerful bactericidal influence is now well recognised, thanks to the work of Downes and Blunt, Duclaux, Arloing, Roux, Geissler, Buchner, and others. From a theoretical point of view, therefore, everything is in favour of the employment of light in the treatment of superficial diseases of the skin caused by bacterial infection, but up to the present this therapeutic agent has been practically neglected.

The few communications on the use of light which I have been able to find in medical literature are all in reference to the treatment of lupus. According to Tillmann,[1] Thayer submitted patients suffering from lupus to the influence of sunlight concentrated by means of a biconvex lens. Thayer appears, however, to have depended chiefly upon the calorific effects of the sun's rays. In a recent work Otterbein[2] mentions a case of lupus which was treated by a layman with a 'burning-glass.' Later, Maximilian Mehl made use of the same procedure.

[1] Tillmann, 'Lehrbuch der allgemeinen und speciellen Chirurgie,' 1895, 4th edit., Allg. Theil., p. 443.

[2] Otterbein, 'Die Heilkraft des Sonnenlichtes,' Trèves. 1896, p. 101.

Finally, Ziegelroth[1] mentions that Dr. Lahmann treated two cases of lupus with the electric light, combined with the use of filiform douches alternately hot and cold.

Lahmann used an arc light of 12 ampères placed at the focus of a parabolic mirror. The sittings were at first of ten minutes' duration, but later half an hour daily. As in this case rays rendered parallel by the parabolic mirror, and not converging rays, were used, the action of the light was manifestly too weak to exercise a bactericidal effect during the short sittings to which the patient was submitted. In fact, if luminous rays could cure lupus, the affection would never be seen upon the face, which is frequently, and for a greater or less length of time, exposed to the rays of the sun, which are more intense than the light used by Dr. Lahmann. These isolated instances of the employment of light for the treatment of lupus are of little value, and can scarcely furnish a basis for later researches. I therefore deemed it necessary to take up the study of this interesting question from the beginning.

I

As the bactericidal effect of light is very slow, it is imperative to concentrate it by means of mirrors or lenses, care being taken at the same time to exclude the heat rays of the spectrum—the ultra-red, red, orange, and yellow—because these rays

[1] Ziegelroth, 'Die elektrische Behandling bei Lupus' (*Blätt. f. klin. Hydrotherapie*, June, 1895, p. 138).

when concentrated cause combustion of the tissues. Moreover, this exclusion has very little influence upon the bactericidal action of light, most observers having agreed that these qualities depend upon

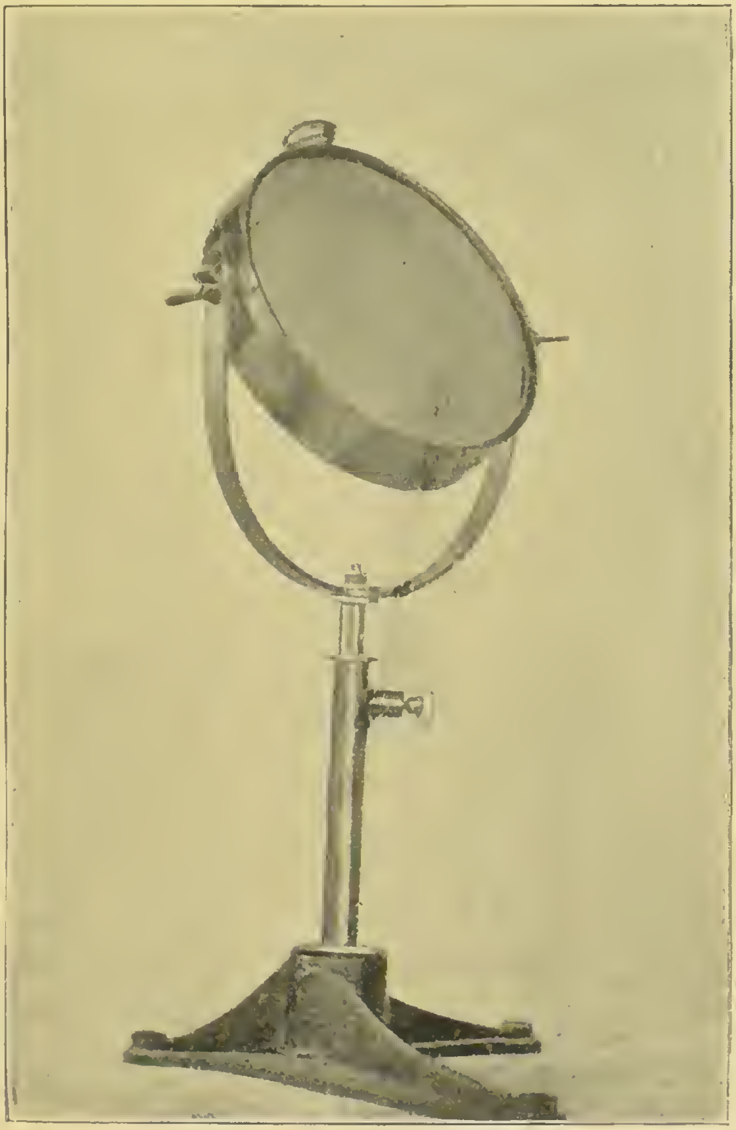

FIG. 4.

the most refrangible rays, a fact which my own researches have confirmed. I have succeeded in excluding all or most of the heat rays by making the light pass through a layer of water coloured by

methylene blue, or through an ammoniacal solution of sulphate of copper. A blue or blue-violet light is thus obtained which is, *par excellence*, bactericidal.

The sun is undoubtedly the best source of light; but as it is not always available, it is necessary to have recourse to artificial illumination, especially to electric light. For this purpose I always use the voltaic arc, for the light given by incandescent lamps contains too few chemical rays.

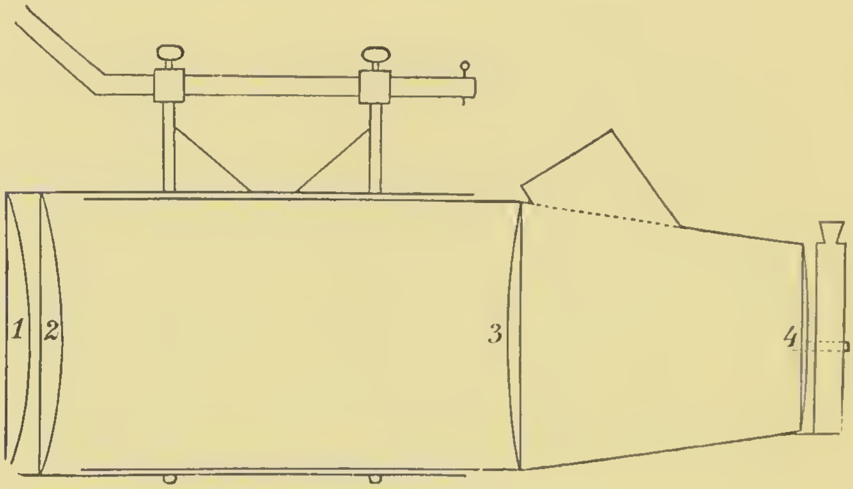

FIG. 5.

The apparatus which I employ to concentrate sunlight consists of a hollow plano-convex lens, 20 to 40 centimetres in diameter, filled with an ammoniacal solution of sulphate of copper and mounted upon a metallic support in the form of a fork, which allows the glass to be moved about a vertical and horizontal axis, and to be raised and lowered at will (Fig. 4).

The rays of the electric light being divergent, instead of parallel like the sun's rays, it is obvious that the apparatus required to concentrate this light necessitates a construction quite different from that which I have just described.

This apparatus, as Fig. 5 shows, consists of two cylinders fitting like the parts of a telescope, and each containing two plano-convex lenses.[1] The lenses Nos. 1 and 2, turned towards the source of light, cause the divergent rays of the arc light to become parallel. Between lenses Nos. 3 and 4, which render convergent the rays made parallel by lenses Nos. 1 and 2, there is a layer of distilled water (10 litres). At the end of the apparatus is attached a very flat cylinder, closed at its two extremities by flat glasses, and filled with an ammoniacal solution of sulphate of copper (light filter). The water and the ammoniacal solution of sulphate of copper are contained, for practical reasons, in different chambers, the distilled water very rarely needing to be changed, whilst the solution of copper sulphate quickly becomes thick, and must be frequently renewed. Besides this, each apparatus is provided with several light filters of different strengths, as the degree of temperature borne by each patient is very variable.[2]

The distance between the two systems of lenses being immaterial from an optical point of view, the two pieces of the apparatus may be brought nearer to each other or separated at will, which is very convenient in practice. The intensity of the arc light used varies from 35 to 50 ampères.

[1] The dimensions of the different lenses of the apparatus are as follows: Lens No. 1—diameter, 25 centimetres; focal distance, 60 centimetres. Lens No. 2—diameter, 25 centimetres; focal distance, 50 centimetres. Lens No. 3—diameter, 25 centimetres; focal distance, 70 centimetres. Lens No. 4—diameter, 18 centimetres; focal distance, 70 centimetres.

[2] The blue light filters are abolished in the more recent apparatus (Trans.).

II

Before constructing and perfecting these apparatus I made sure, by a series of experiments, that the bactericidal action of light does actually increase in proportion as the rays are concentrated. For this purpose I had recourse to a method of plate culture used by Buchner[1] in his researches on the action of light upon bacteria. I took two flat rectangular bottles, which I coated on the inside with gelatine-peptone, or gelose-peptone, and sowed these with pure bouillon cultures of *Bacillus prodigiosus*—sometimes, also, with Eberth's bacillus or the anthrax bacillus. On the outside of each bottle I gummed a sheet of paper, white on one side and black on the other, the white surface being turned towards the light, so as to avoid the absorption of the heat rays, and the black surface towards the glass, with the view of preventing the light influencing the culture. Besides this, I made several round openings in the paper, across which I traced on the glass of the bottle numbers in Indian ink, indicating in minutes the time during which the parts were subject to the action of the light.

At the end of from one to two hours after the inoculation, two flasks thus prepared were simultaneously exposed, one to direct sunlight, the other to concentrated sunlight. They were then kept for from one to two days in darkness, and at the end of this time the result of the experiment was obvious

[1] Buchner, 'Ueber den Einfluss des Lichtes auf Bakterien, und über die Selbstreinigung der Flüsse' (*Arch. f. Hygien*, xviii., p. 179).

at a glance. In fact, the numbers indicating the space of time in which the light had killed the bacilli were clearly marked on the culture by the colonies which had developed in the shelter of the parts coloured black. In this manner the bacteria themselves indicated the time of exposure necessary to kill them. Numerous researches of this kind have shown me that sunlight, concentrated by means of my apparatus, kills microbes fifteen times more rapidly than direct light, and that the effects of concentrated arc-light are very much more intense.

III

It is known that living tissues are permeable to light. The skin, muscles, tendons, nerves, cartilages, and even the bones—as is proved by the illumination of bony cavities by transparence—permit the penetration of luminous rays. As the presence of oxygen is necessary for light to produce its bactericidal action, and as, on the other hand, the blood is the constituent of the tissue which contains the greatest quantity of this gas, I believed at first that it would be advantageous to produce an artificial hyperæmia in the areas submitted to the therapeutic action of the light, but experience was not long in showing me that that supposition was erroneous.

In fact, if a fragment of albuminous photographic paper (*papier ariosto*) is placed upon the pavilion of the external ear, and a cone of blue-violet light from the solar apparatus is made to fall upon the other

surface of the ear, there is no reaction upon the sensitive film at the end of five minutes. But when, by means of two plates of glass, the auricle is compressed until it becomes exsanguine, it is found at the end of twenty seconds that the photographic paper has become black. It follows, therefore, that the blood prevents the penetration of the chemical rays through the tissues in a remarkable manner.

In my therapeutic experiments I have therefore sought, as far as possible, to exclude the blood from the regions to be submitted to the action of light. I have had constructed different compressing apparatus composed essentially of a slightly convex plate of glass enclosed in a metal ring furnished with two or four prolongations. By the aid of elastic bands attached to the prolongations and passed round the head, the apparatus can be fixed in such a manner as to exercise at a given point a uniform and continuous pressure (Fig. 6). These glasses are of various forms and dimensions: flatter for the forehead and more convex for the cheeks.

IV

I have employed the method of treatment by concentrated chemical rays in different bacterial dermatoses, but especially in lupus vulgaris, a disease which presents conditions peculiarly favourable for the carrying out of this therapeutic measure. On the one hand it is known that lupus vulgaris is caused by the tubercle bacillus, that it is a local

Fig. 6.

To face p. 70

Fig. 7 (A).—Before treatment.

Fig. 7 (B).—After treatment.

disease, and generally quite superficial; on the other hand it is well established that light is capable of killing the *Bacillus tuberculosis*.

My method of procedure is as follows.

During a period varying from several days to several weeks an area from 1 to 3 centimetres in diameter is submitted to the influence of the chemical rays for at least two hours daily. [With the newer apparatus the time has been reduced to one hour.—TRANSLATOR.] When a spot appears to have been sufficiently treated, another undergoes the same process, and in this manner the treatment is continued from spot to spot, until the whole of the affected area has been subjected to the light. If suspicious spots are then recognised, they are again treated. In addition to this, the patient is inspected from time to time—as a rule, after the lapse of some months—and further treatment undertaken, until no further lupus spots are found.

Each patient is attended by a nurse, whose care it is to keep the spot in focus, and to see that the light falls perpendicularly upon the pressure-glass.

As I have already had occasion to remark (p. 11), the chemical rays cause a rather severe erythema of the skin, which varies with the greater or less intensity of the light, and also with individual idiosyncrasy. Sometimes there is œdema, and rarely vesication, with the subsequent formation of crusts.

When a lupus patch has been sufficiently treated, the previously raised margins become flat, the redness disappears, and a normal appearance is the result, and the ulceration, if such were present, cicatrizes. The scars have an excellent appearance.

Can lupus recur after this method of treatment? It is at present impossible for me to speak definitely on this point, as I have only carried out the method described for two years. However, everything points to the conclusion that, with regard to recurrence, this method may be expected to give results which, up to the present, have not been attained by any other treatment, and for several reasons.

First, the lupus eruption is never seen to increase in extent from the time that the light treatment is started, provided that care is taken to begin at the margins of the patch, and to direct the light in such a manner as to act simultaneously upon the apparently healthy skin which immediately surrounds the erruption. In the second place, the effects of the light continue to be produced even after the cessation of the treatment. Thus suspected spots are sometimes seen to disappear spontaneously at the end of several months. This fact shows that the tubercle bacilli are killed long before the transformation of the diseased tissue with its red-brown appearance into healthy tissue of a white colour—a change which is only brought about later, and after the lapse of time.

The opposite result is also sometimes seen; patients who are believed to have been cured have returned after a time with macules of lupus in the stage of development. It would appear that these are not cases of recurrence, but of diseased foci, which have passed unrecognised at the time of treatment, and which did not fail to yield to the influence of a new exposure to light.

As to true recurrences, I have not yet observed

any. But while admitting that they may exist, they certainly do not present themselves except in the form of spots which rapidly disappear under the action of the chemical rays. I may add that during the last six months I have treated some cases of lupus by an improved process, the therapeutic effect of which is extremely rapid, and which consists in using a voltaic arc light of 80 ampères, with lenses of rock crystal. This substance allows the ultra-violet rays of the spectrum which are absorbed in great part by ordinary glass to pass, and the bactericidal action of these rays is much more powerful than that of the visible chemical rays. By means of this process I have succeeded in killing the *Bacillus prodigiosus* in one minute, and I have observed cases of lupus, in which the lesion was the size of a pea, completely disappear after having been subjected for only fifteen to twenty minutes to the action of the ultra-violet rays. Unfortunately, lenses of rock crystal are expensive, and they can only be procured of small dimensions.

The greatest fault of the procedure is its slowness. There are cases in which real improvement has only been observed at the end of three or four months. Happily this inconvenience has already in great part disappeared, as the result of the employment of a very strong light and of lenses of rock crystal. Moreover, the method is obviously capable of improvements.

The following plates, which represent patients before and after treatment by light, will, I hope, be able to give a sufficient idea of the good effects of light upon lupus: Figs. 7, 8, 9, and 10.

I have had fifty-nine cases actually under treatment, and followed long enough to judge of the results obtained. The cases have differed greatly in form, extent, and duration, which varied from two to forty years.

The patients, with only one exception, have been much benefited. Twenty-three are cured—at least, in appearance—and thirty are still under treatment. Some of these last are almost well, and the cure of the others appears to be merely a matter of time. Six patients have been obliged to give up the treatment for non-medical reasons.

It will be seen that these are very encouraging results, which can only encourage perseverance in the method which I have just described for treating a disease so common and so rebellious as lupus.

FIG. 8 (A).—Before treatment.

FIG. 8 (B).—After treatment.

To face p. 74

APPENDIX

By James H. Sequeira, M.D.

Owing to the pressure of other work, Dr. Finsen found himself unable to write an appendix to the above paper, and has asked me to bring the subject up to date by a résumé of a paper by Dr. Forchhammer, who is in charge of the clinic at the Finsen Light Institute in Copenhagen. This paper, entitled 'The Finsen Treatment and its Present Position in Dermatology,' was read at the Congress of the German Dermatological Society at Breslau this year (1901). A large part of it is statistical, and although it is very difficult to present an adequate idea of the value of any form of treatment in this manner, the number of patients who have been treated at Copenhagen is now so large that the communication is of great value. The difficulty is to classify the cases of lupus vulgaris according to their severity, and Dr. Forchhammer presents two tables. In one the cases are grouped roughly, according to the area of the disease. Cases are called 'extensive' when the lupus patch is of more than 50 square centimetres in area (about the size of a playing card), and 'slight' when the diseased area is less. In the second table the cases are classified according to their duration before treatment was begun.

The treatment is divided into chief treatment (*Hauptbehandlung*), and after-treatment (*Nachbehandlung*). The latter is the application of light to spots which appear after the chief treatment is completed (see p. 72).

TABLE I.

CASES OF LUPUS VULGARIS TREATED AT THE LIGHT INSTITUTE, COPENHAGEN, TO THE END OF DECEMBER, 1900.

	Slight Cases.	Extensive Cases.	Total.
(1) Chief treatment completed ...	331—83 %	125—52 %	456—71 %
(2) Under treatment	45—11 %	72—52 %	117—18 %
(3) Treatment abandoned ...	25— 6 %	42—18 %	67—11 %
	401	239	640

TABLE II.

THE SAME CASES, CLASSIFIED ACCORDING TO DURATION.

	Less than 10 Years.	More than 10 Years.	Total.
(1) Chief treatment completed ...	265—78 %	191—63 %	456—71 %
(2) Under treatment	49—15 %	68—23 %	117—18
(3) Treatment abandoned ...	25— 7 %	42—14 %	67—11 %
	339	301	640

Of the 456 cases in which treatment had been completed at the end of 1900, no fewer than 130 are known to be free from recurrence for from one to five years. For the rest the period of observation is shorter.

Of the 117 cases under treatment, there is a prospect of a successful result in 42; 53 are obstinate cases, where the treatment is very tedious and the outlook is less favourable; and there are 23 cases of recurrence under treatment.

The cases in which the treatment has been abandoned demand consideration. Of the 67 patients,

Fig. 9.—Treatment with concentrated sunlight.

To face p. 76

there was an unfavourable result in only 11; and from my own knowledge of the severity of the disease in many instances—for the worst cases in Scandinavia gravitated to the Finsen Institute—this is a remarkably small proportion. Six patients left to undergo the light treatment elsewhere. In 35 instances the patients were suffering from other severe ailments—in some cases fatal—and 14 left for non-medical reasons. When the length of time which is required for satisfactory treatment is considered, these figures are remarkable.

Extensive fibrous scars, intense brown pigmentation, and much secondary infiltration, were found to lead to prolongation of the treatment. Mucous membrane lesions and tubercular disease of the internal organs, while not materially influencing the healing of the skin lesions, were found to favour recurrence of the disease.

Infiltrations were treated by pyrogallic acid ointment; and boric acid fomentations were employed to clean the surfaces before the application of the light.

Of other diseases, verrucose tuberculides of the skin were found to be favourably influenced by the light, but scrofulides of the subcutaneous tissue were unaffected.

Of 44 cases of lupus erythematosus, 14 were cured, and 15 improved. Favourable results were obtained in the early cases.

Forty-nine cases of alopecia areata were treated, of which 30 were cured.

Twenty-four cases of rodent ulcer and cancroid were treated, with a favourable result in 11.

Of 25 cases of acne vulgaris which had resisted ordinary measures, 13 were cured.

No benefit was seen in cases of favus, ringworm, and sycosis.

Nineteen cases of nævus vascularis planus were treated. In a few instances the disfigurement entirely disappeared; in others the colour diminished in intensity.

Attached to Dr. Forchhammer's paper is a series of reports from other workers in the same field. Dr. Sabouraud (Hôpital St. Louis, Paris) considers that Finsen's method is the 'specific treatment' for tubercular lupus. Dr. Burgsdorf, of the University Dermatological Clinic at Kasan; Professor Lortet and Dr. Genoud, of Lyons; Professors Petersen and Wiljaminoff, of St. Petersburg; Mr. Malcolm Morris and Dr. Dore, of London; and Dr. Leredde, of Paris, all report the excellent results which they have obtained. My own experience at the London Hospital, where nearly 200 patients have now been under treatment, amply confirms that of Dr. Forchhammer.

In every case of lupus vulgaris the application of the treatment has been followed by improvement, and some of the patients have been free from recurrence for over twelve months. The only drawback is the expense and the length of time necessary for the adequate treatment of extensive areas of the disease; but with a simpler apparatus, such as that of Lortet and Genoud, a modification of which I have used with success, and the more recent device of Dr. Bang of Copenhagen, there is every reason to believe that this difficulty will, in great

FIG. 10.—Treatment with concentrated electric light.

To face p. 78

part, disappear. The great merit of the new apparatus is that the time of exposure is much reduced.

At a discussion upon the Finsen method at the Annual Meeting of the British Medical Association at Cheltenham this year (1901), the beneficial results of the treatment were generally recognised.

THE END

BILLING AND SONS, LTD., PRINTERS, GUILDFORD

AN ELEMENTARY TEXT-BOOK OF MECHANICS. By R. WORMELL, D.Sc., M.A. With 90 Illustrations. Crown 8vo., cloth, 3s. 6d.

*** *Solutions to Problems for Teachers and Private Students.* 3*s.* 6*d.*

A TEXT-BOOK OF ZOOLOGY. By G. P. MUDGE, A.R.C.Sc. LOND., Lecturer on Biology at the London School of Medicine for Women, and the Polytechnic Institute, Regent Street. With about 200 original Illustrations. Crown 8vo. [*In the Press.*

A HANDBOOK ON FERMENTATION AND THE FERMENTATION INDUSTRIES. By CHARLES G. MATTHEWS. Fully Illustrated. Crown 8vo. [*In the Press.*

A MANUAL OF THE NATURAL HISTORY AND INDUSTRIAL APPLICATIONS OF THE TIMBERS OF COMMERCE. By G. S. BOULGER, F.L.S., F.G.S., A.S.I., Professor of Botany and Lecturer on Forestry in the City of London College, and formerly in the Royal Agricultural College. [*In the Press.*

WORKS BY PROFESSOR C. LLOYD MORGAN, F.R.S.

ANIMAL BEHAVIOUR. By C. LLOYD MORGAN, F.R.S., Principal of University College, Bristol, author of 'Animal Life and Intelligence,' etc. With numerous Illustrations. Large crown 8vo., 10s. 6d.

OUTLINE OF CONTENTS.—I. Organic Behaviour—II. Consciousness—III. The Mental Faculties of Animals—IV. Heredity and Evolution—V. Instinctive Behaviour—VI. Intelligent Behaviour—VII. Some Types of Animal Behaviour—VIII. Social Behaviour—IX. Emotional Behaviour—X. The *rôle* of Consciousness in Evolution.

HABIT AND INSTINCT. By C. LLOYD MORGAN, F.R.S. viii + 352 pages. With Photogravure Frontispiece. Demy 8vo., cloth, 16s.

The earlier chapters contain the author's original observations upon the young of many species of birds and mammals. These are followed by an interesting discussion upon Animal Habits and Instincts, and the work ends with chapters on 'The Relation of Organic to Mental Evolution,' 'Are Acquired Habits Inherited?' 'Modification and Variation,' and 'Heredity in Man.'

'An admirable introduction to the study of a most important and fascinating branch of Biology, now for the first time based upon a substantial foundation of carefully observed facts and logical induction from them.'—Professor ALFRED RUSSEL WALLACE.

PSYCHOLOGY FOR TEACHERS. By C. LLOYD MORGAN, F.R.S. xii + 251 pages. Crown 8vo., 3s. 6d.

CONTENTS.—States of Consciousness—Association—Experience—Perception—Analysis and Generalization—Description and Explanation—Mental Development—Language and Thought—Literature—Character and Conduct.

'The author of this book speaks with special emphasis and authority, and his remarks will be found of exceptional value to students.'—Sir J. G. FITCH, *in the Preface.*

ANIMAL SKETCHES. By C. LLOYD MORGAN, F.R.S. viii + 312 pages, with 52 illustrations (many of them full-page). Crown 8vo., cloth, 3s. 6d.

$\frac{LR}{tR}$